THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VII.

No. XII.—DECEMBER, 1910.

ORIGINAL ARTICLES.

I.—The Relation between the Foliated and non-Foliated Rocks of Southern Nigeria, West Coast, Africa.

By John Parkinson, M.A., F.G.S.

A CONTRIBUTION by Messrs. Horwood & Wade[1] to the Geological Magazine for November, 1909, calls attention (p. 505) to certain papers by me on the relation between the gneisses and schists and the later granites of Southern Nigeria.

Since these papers were published in 1907 I have had the opportunity of visiting the western parts of Liberia, a considerable proportion of the littoral of the Gold Coast Colony, and on two occasions have spent some time in Southern Nigeria. These expeditions have served to impress upon me the close resemblance existing between the crystalline rocks of these widely scattered regions, a resemblance so marked as to suggest a common origin. The following notes on the petrology of the Oban Hills in Southern Nigeria may throw some light on the relation between the schists, the gneisses, and the granites of this part of West Africa.

A study of the crystalline axis of the Oban Hills shows that, while the rocks may be conveniently grouped under certain heads, yet this arrangement must remain largely an artificial one. Acid orthogneisses occupy by far the greater portion of the central part of the area, and are, as it were, represented or replaced by a number of granite bosses westward in the neighbourhood of the Iyangita, an important tributary of the Calabar River. A short investigation shows that the gneisses include a variety of types, the mutual relations of which prove that they differ in age the one from the other to at least some extent. I have grouped these together into a single series: firstly, on account of their general petrographical similarity; secondly, on account of similarity in habit, e.g. the frequent occurrence of a streaky or of a banded structure; and, thirdly, on account of the occurrence of special but widely distributed petrological types, e.g. a garnet-granulite.

In addition, comparison of a suite of specimens in the field shows that rocks petrographically granites pass by insensible gradations into these gneisses. Whatever the agent which produced the foliation in the one, it was clearly non-operative during the solidification of

[1] "The Old Granites of Africa."

that part of the series represented by the other. In some localities no hard and fast line can be drawn between a series of specimens which, taken individually, exhibit many differences, and which have been collected over a distance to be measured only by a few yards. Distinctly later, though the difference in age need not, geologically, be very great, are the granites of the Iyangita, of Itara, and numerous other localities, where now and again we may see these rocks clearly intrusive into the Gneissose Series. To work back a stage in the geological sequence we must appeal to the schists of the Calabar River at the Ekankpa Ford, south-east of Isbofia, of the Kwa River at Abuton, and of the Akpa Iyefe.[1] In each locality (and the three given could be supplemented by others from the eastern and north-eastern parts of the hills) is a well-marked group of mica- and hornblende-schists, associated with granulites, and riddled by acid intrusions. In the first and second a banded gneiss is produced by a kind of *lit-par-lit* injection; in the last the dissemination of the acid magma was irregular. In regard to the nature of the intrusions, the first is now a granitic gneiss; the second a granitic gneiss associated with a coarser rock of pegmatoidal habit; in the third, the rock is practically a pegmatite. To these petrographical types the remainder of the district affords many resemblances, amounting often to identities. Pegmatites crushed and uncrushed are distributed sporadically, but far from uncommonly, over the entire area, carrying tourmaline, garnet, and muscovite as accessory minerals; here and there, e.g. near Netim, Awi, Aking, Awöfong, and Mkpot, mica- and hornblende-schists appear, petrographically to be correlated with those of Abuton and the Akpa Iyefe.

The typical *mica-schists* of the Akpa Iyefe on the Kamerun frontier are rather massive rocks, not conspicuously laminated, and with a tendency to become gneissose. On applying a low-power hand-lens quartz and felspar become apparent, although crystals of either mineral are here and there discernible to the naked eye. In some specimens an indication of banding is noticeable. The attempt at a gneissose structure in the schists is obvious in many places, and is of interest in relation to the very close association they have to the intrusive granite. Possibly the structure is due to material which permeated from the acid magma, as I have suggested elsewhere[2] in referring to the work of Lacroix and others.

In two instances clear evidence is obtained of partial liquefaction and incorporation of a micaceous schist by a rock of granitic composition. The first of these is from a creek above the Falls of the Akpa Iyefe; the second a gneissic band in the very similar mica-schists of the river bed above Mkpot. In slides prepared from these rocks can be studied the partial solution of felspar, muscovite, and biotite by an agent which generally is felspar, but occasionally quartz.

In the Mkpot example blunt tongues of felspar (apparently albite) frequently containing *quartz vermiculé* have forced their way through the edges of the original porphyritic orthoclases of the younger rock.

[1] See outline map of the Oban Hills, Q.J.G.S., vol. lxiii, p. 314, 1907.

[2] Q.J.G.S., vol. lvi, p. 316, 1900.

This is a fine-grained porphyritic biotite-gneiss. The microscopical character of the mica-schists of the lower reaches of the Akpa Iyefe need be but briefly described. One of the most typical examples taken from about half a mile below the Falls is distinguished by the abundance of a reddish-brown and reddish-yellow mica. The mineral forms exceedingly irregular and tattered flakes, which are always small. Less common than this biotite, and associated with it, are crystals of muscovite. Quartz and an acid plagioclase build up the greater part of the rock.

Other specimens contain nearly equal quantities of biotite and hornblende. Quartz is locally very abundant; the plagioclase may be of rather a basic variety; sphene and apatite are accessory minerals.

The pegmatoid granites associated with the mica-schists of the Akpa Iyefe are a well-marked group. The clearly intrusive nature of these rocks and the closeness of their relations to the schists, the one succeeding to the other without sign of chilled edges and with the utmost irregularity, make them of some interest. Their texture varies considerably; some coarse varieties, forming ill-defined veins, are remarkable for their large pink orthoclases and lump-like masses of quartz having a pegmatoid habit. Doubtless they differ slightly in date of intrusion. Small brownish-red garnets, plates of muscovite occasionally about an inch across, and, not least important, small nests and crystals of black tourmaline are usual accessories. Biotite is found occasionally, but rarely in quantity. Except some aplite dykes, these coarse varieties appear to be the youngest members of the series, and form irregular veins in a finer-grained rock of essentially the same composition and appearance.

The mica-schists of the Kwa River in the neighbourhood of the Falls below Abuton are usually reddish-brown close-textured rocks, remarkably well foliated. The mica is by far the most conspicuous mineral. In other specimens the rocks are very massive, brownish-black in colour, and speckled with crystals of felspar. Now and again hornblende-schists occur sparingly. Characteristic of the neighbourhood is the occurrence of a tourmaline-bearing garnetiferous gneiss, which is associated with the schists so closely as to produce a beautifully banded rock by a process apparently of *lit-par-lit* injection.[1] This banding is sometimes on a broad scale and not very clear, and at others finer and exceedingly regular. Now and then the two rocks interlock in wedge-like forms, while the intrusive nature of the more acid is shown by the presence of fragments of the schists, more or less disintegrated, contained by it.

The Gneisses.—Descriptions of a few sections at and between the villages of Netim and Ibum on the western side of the Oban Hills will serve to show the nature of the gneiss of the country.

At the first stream north of Netim on the Netim-Ibum path the oldest rock is a biotite-hornblende-schist rich in the ferromagnesian minerals, and containing some quantity of a yellowish-green constituent, probably epidote. This passes into a biotite-gneiss, or,

[1] Compare G. A. J. Cole on the production of banded gneisses by the incorporation of sedimentary and igneous material by an invading granitic magma ("Marginal Phenomena of Granite Domes": Rep. Brit. Assoc., 1905).

I believe, more accurately, the latter is intrusive. In places this is almost a granite, and is characterized by porphyritic crystals of orthoclase, half an inch or so in length, often retaining their rectangular outlines. Now and again these rocks are cut by a second gneiss, also containing biotite, though not in great quantity, and distinguished from the first by containing no phenocrysts and by being on the whole of finer texture. Distinct in certain localities, no hard and fast line probably exists in reality between the two. A differentiation obvious in one place had not apparently taken place in another.

Associated with these rocks, and clearly later in date than they, are masses and veins of a coarse pegmatite (the crystals of pink orthoclase may be a couple of inches in length), and here and there aplite veins still later in date cut through the whole.

To avoid misconception it should be stated that, in this locality, the biotite-hornblende-schist above mentioned exists only as fragments, and not in well-defined exposures free from acid intrusions. The evidence rests on lenticular bands and inclusions with torn and frayed-out edges passing more or less rapidly into the surrounding gneiss.

In such a series it is useless to expect constant lithological types, and the country between Netim and Ibum, a distance of 24 miles, provides examples to show that every gradation exists between the rocks above mentioned. The principal points are born out by the excellent exposures of rock on the Calabar River and on an important tributary joining the main stream where it is crossed by the Ibum Path, a few miles south of that village. Near the path a biotite-granite is the predominant rock, but higher up the main stream irregular fragments of a fine micaceous gneiss or schist are contained in a gneiss of more acid composition. The biotite in the former rock forms minute flakes, and the quartz and felspar cannot be differentiated by the naked eye. Later than either is a coarse quartz-orthoclase-plagioclase rock, some of the quartz grains being nearly a quarter of an inch in length. This is a pegmatite.

Examination of thin sections shows that in the micaceous gneiss or schist reddish-brown flakes of biotite are the only coloured constituent, with the exception of a few grains of an iron oxide and some small garnets. The felspars are represented by microcline, orthoclase, and an acid plagioclase, quartz is rather less abundant than the felspars, and exhibits crush shadows. The structure of the rock is granulitic, and *quartz de corrosion* occurs here and there. The more acid gneiss consists almost entirely of quartz and of felspars of the same varieties as in the first instance. Lobed growths of *quartz vermiculé* in felspar are common. The rock differs but little from a granite.

Passing to the tributary stream above mentioned we find the irregular relation of basic to acid components giving place to a regular banded structure, occasionally well developed over a comparatively large surface of rock. Relation to the more irregular type is shown by the ends of a band tailing out into elongated wisps or streaks.

The rapid loss of foliation, by which the gneisses pass into granites, may be studied between the Calabar River and Ibum. The former rock contains angular inclusions, i.e. more basic patches, obliquely

truncated by one more acid; these occur also as streaks and irregular bands. Comparison of a series of specimens taken from a distance of about four yards demonstrates a passage between granite and gneiss, the only differences being distinctness in foliation and banding of the mica; texture and bulk composition remaining the same.

The Granites.—Under this heading are placed all the later intrusive masses of acid composition, distinct from those grading into gneisses. They vary greatly in composition; doubtless they vary greatly in age.

One of the best-marked masses in the Oban Hills is the strikingly porphyritic rock of Itara. It is found near the word 'Huts' (in the map of 1903), to the north of the village of Ikuri, and extends southwards along the drainage basin of the Ukpong River, almost as far as Ibum. The rock is a biotite-granite, rich in quartz, and containing a multitude of crystals of pink orthoclase, occasionally a couple of inches in length. In a thin section the characteristic mica is of a yellowish-green colour; sphene and an epidote are common, and small crystals of apatite are not rare. The order of consolidation was apatite, sphene, epidote, biotite. Locally the rock is cut by aplite dykes. The typical granite of Ibum, near the headwaters of the Ukpong River, is a fine-grained, non-porphyritic rock containing sufficient biotite to give it a well-marked speckled appearance. Quartz is plentiful, and in places a suggestion of foliation may be noticed.

About $1\frac{1}{2}$ miles north of the small river called 'Ndi 'Ncha, between Ibum and Netim, I found a small boss of a rather peculiar granite. The rock is of a medium degree of coarseness, characterized by blade-shaped and apparently homogeneous crystals of hornblende, scattered without orientation through the rock. Thin sections show these to consist of grains of green hornblende mingled with flakes of biotite. In some respects this rock, which has undergone a considerable amount of crush, is not quite a normal granite. Thus both ferromagnesian minerals enclose numerous grains of quartz or are greatly indented by them in a semi-poecilitic manner, the crystallization dates of the two minerals not being very different. Lobed outgrowths of felspar containing *quartz vermiculé* are also common. Microcline is absent, orthoclase predominates, although albite or oligoclase is abundant. Apatite is exceptionally plentiful, and one slide contains some interesting crystals and grains of white sphene.

The granite forming the left bank of the Calabar River, one quarter of a mile above Uwet (now being quarried by the Public Works Department), is of a grey-coloured uniform rock of medium texture, practically devoid of hornblende or mica. The rock is composed of almost equal proportions of quartz and felspar; the latter includes orthoclase, microcline, and an acid plagioclase. Numerous small flakes of muscovite and occasionally granules of impure calcite are developed in the felspar, the former not seldom in considerable quantity.

At 'Nsibimba, on the eastern side of the hills, is a very hard and massive biotite-granite containing rare garnets and muscovite; quartz and orthoclase are both abundant, and together build up practically the whole of the rock, for a triclinic felspar is exceedingly scarce. The rock has been only slightly modified by pressure.

The granite of Uwet differs considerably from the granites found between the Calabar River and the Iyangita in the neighbourhood of Uyanga and Ojo 'Nkorimba. The latter recalls the porphyritic granite of Itara in containing sphene as an important accessory constituent, and, in the presence of a mineral resembling epidote, certainly of primary origin, the identification being at present doubtful.

The rock from the Iyangita towards Iwudu contains some quantity of a strongly pleochroic green hornblende, and traces of the same mineral appear in the granite north of Ojo 'Nkorimba. Well-built crystals of brown biotite are conspicuous in all slides examined from this part of the district. Orthoclase is the predominant felspar; but the rock a short distance south of Uyanga contains large crystals of microcline, as does also a specimen collected between the Iyangita and Calabar Rivers. The plagioclases, commonly zoned, appear to be albite or oligoclase, or both. Large grains of quartz are plentiful, and *quartz vermiculé* is common and characteristic. In some specimens tourmaline occurs, but it is very rare. One or two of the rocks have been very slightly crushed.

The red aplites, which are apparently the latest igneous rocks of the lower Akpa Iyefe (for basalt dykes are not seen), consist of an aggregate of felspar and quartz, the former mineral slightly preponderating over the latter. Micropegmatite, the possible presence of which is suggested by the hand-specimen, is found to be but feebly represented; a thin, not very well defined rim of intergrowth is, however, usual where quartz and felspar meet. A point of some interest lies in the composite nature of the felspars; due, either to an almost complete resorption of an early generation of the mineral, or to a later influx of felspathic material which has partially dissolved the pre-existing mineral and embedded the fragments within its own substance.

Aplites also cut the porphyritic granite of Itara (along the valley of the Ukpong River). The same rocks, intrusive in hornblende-schists, are conspicuous in a creek running into the Agboyip River, itself a tributary of the Ukpong; and to the north of the village of Awi (south of Nsan), etc.

In distinguishing between the granitic gneisses and the later granites mention may be made of the fact that, as a systematic investigation of the alluvial deposits proves, monazite is characteristic of the former.

II.—On a Drift at Bostall Common, near Plumstead.

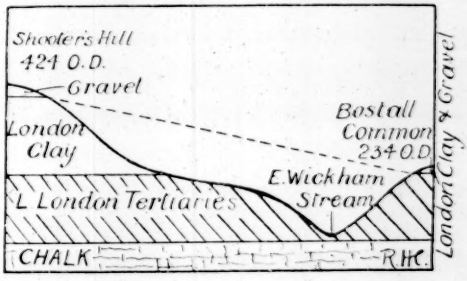
By R. H. Chandler.

CAPPING a small patch of London Clay on the highest part of Bostall Common (234 O.D.[1]), there is a 'drift' that presents peculiarities identical with part of the gravel on Shooters Hill (2 miles distant) at 424 O.D.[1]

The gravel at Shooters Hill has been frequently described, so

[1] Both these heights are the highest points of the drift.

need not be detailed here. It consists of a coarse, clayey gravel of rounded flint pebbles and beds of sand. Some of the pebbles are very much corroded outside, split into several pieces, and present curious coloured zonings.[1] Lower Greensand chert and quartz pebbles are rare, and quartzite pebbles very rare. A very characteristic feature is the presence of the above-mentioned corroded, split, and zoned pebbles. The rough cortex of the pebbles show knobs and pits as though partly decomposed by an acid, and for which no other word than 'corroded' seems applicable. The splitting may be along any axis, but is frequently parallel to the long one, and is not the usual frost shattering or pitting; a pebble may be found in three or four pieces and the pieces close together, as though the fracture were of recent origin. The zoning is also curious, and some pebbles show (on the split surfaces) several differently coloured concentric bands, evidently due to weathering and staining. An interesting point about these corroded and zoned pebbles is that the inner zone is frequently of an opaque cream colour, and is surrounded by brown, black, red, or other coloured translucent flint, and then comes the cream opaque cortex; whereas in ordinary weathered flint pebbles the translucent part is in the centre. These three points (i.e. corroding, splitting, and peculiar zoning) at once claim attention, and serve to give a characteristic feature to the gravel, and to distinguish it from the other 'Hill', or 'Terrace' gravels of the surrounding district.



Section from Shooters Hill to Bostall Common showing the relation of the 'drifts' and the erosion by the East Wickham stream. Horizontal scale 1 inch = 1 mile, vertical $\frac{1}{4}$ inch = 100 feet.

The Shooters Hill gravel rests on about 180 feet of London Clay and, as a recent section showed, Bagshot Sand in places.[2] The drift at Bostall Common caps the highest part of the Common, which consists of a circular patch of London Clay, about 100 yards in diameter and about 10 feet thick, and is separated from Shooters Hill by $1\frac{1}{2}$ miles of Blackheath, and Woolwich and Reading Beds (see Section). The gravel occurs as a thin sprinkling on the surface

[1] Mentioned by Dr. A. E. Salter from notes by Mr. A. L. Leach, *Woolwich Surveys*, 8vo, p. 19, Woolwich, 1909.

[2] A. L. Leach, Geol. Mag., Dec. V, Vol. VII, pp. 405–7.

of this small patch of London Clay, and agrees very closely in composition with the Shooters Hill gravel at a level of about 200 feet higher.

The extent of the spread of drift was revealed during the last two winters, when the top of the hill on Bostall Common was removed by the London County Council unemployed, and all the moderately large stones hand-picked and placed on one side. By looking over these heaps it was possible to form an accurate opinion of the composition of the drift, and it was then that the similarity to Shooters Hill gravel became so apparent. I have had the corroded, split, and zoned pebbles here in abundance, also two quartzite pebbles (this quartzite is curiously marked — precisely like one obtained from Shooters Hill), and a piece of the Lower Greensand Chert. Quartz pebbles I have not found, but as they would probably be small (as at Shooters Hill) they would not stand such a chance of being picked as the larger pebbles; this may account for their apparent absence.

The height of 234 O.D. is above any of the terraces associated with the Thames in this neighbourhood; moreover, the gravel is different from the Terrace gravels in that it contains no (or very few) subangular flints, no Bunter quartzite, Rhanella chert, or igneous rocks, all of which are plentiful in the terraces.

Mr. F. C. J. Spurrell has suggested[1] that this drift might be the remains of a Boulder Clay, or of its subjacent gravel, but considering its curious composition I suggest that it is more likely to have been derived as a 'trail' from the gravel on Shooters Hill, at a time when that mass of London Clay and its capping of gravel was much more extensive than at present. A reference to the sketch will show that this source of supply has been cut off for a long time; for the East Wickham stream, which rises on the slopes of Shooters Hill (as soakage from the gravel), and finds its way to the Thames at Plumstead, has now separated the patch of London Clay at Bostall Common from the mass of Shooters Hill by a valley 150 feet deep (in the line of section), and there has been uncovered an outcrop of the Lower London Tertiaries 1½ miles wide.

An alternative hypothesis is that the Bostall Common drift was once continuous with Shooters Hill gravel and at about the same level, and that it has been separated from Shooters Hill by the cutting back of the East Wickham stream, whilst denudation has lowered Bostall Common vertically from about 404 feet O.D. (the height of Shooters Hill less the gravel cap) to 234 feet O.D., by reducing the London Clay from 180 feet to 10 feet; possibly because its original capping of gravel was not so thick, and hence unable to act so protectively.[2]

The suggested hypothesis seems more workable (i.e. a trail from Shooters Hill down the slope of London Clay), and this feature

[1] "A Sketch of the History of the Rivers and Denudation of West Kent, etc.": Proc. W. Kent Nat. Hist. Soc., 1886, p. 19. This appears to be the first and only reference.

[2] There is a remarkable agreement between these figures.

may be seen at the present day at Swanscombe, in the tramway cuttings of the Associated Portland Cement Company, where foundered London Clay and its capping of gravel (different from that on Shooters Hill) trail down from Swanscombe Hill (300 feet O.D.) to about the 100 feet contour-line; the chief difference between the case of Bostall Common and that of Swanscombe being that at the latter locality the source of supply has not been cut off by a later stream, and that at the former the London Clay appears to be in situ and the drift only to have trailed.

III.—The Great Oolite Section at Groves' Quarry, Milton-under-Wychwood, Oxfordshire.

By L. Richardson, F.R.S.E., F.G.S.

On the occasion of a recent visit to the quarry in the Great Oolite at Milton-under-Wychwood, which has become known amongst geologists as "Groves' Quarry, Milton", Mr. E. T. Paris, F.C.S., and I were disappointed to find that no quarrying operations were in progress and that apparently they had ceased for good.

Messrs. Groves Brothers worked the quarry from 1846 onwards for about fifty years; but then it was acquired by a firm who afterwards traded as "The Taynton and Guiting Quarries, Limited". The Great Oolite limestone that was worked here obtained considerable repute in building circles and was of two kinds. One was derived from the whitish beds that weather into great block-like masses; and the other, from the yellower beds at the base. In the trade, both kinds were known as 'Taynton Stone'; but the first was described as 'No. 1', and said to be "a fine-grained, cream-coloured oolite"; while the second was denominated 'No. 2' and was stated to be a "similar stone, but a shade warmer".

As the faces of the workings are in danger of becoming partially hidden, and the lower beds certainly will become more and more obscured as additional talus accumulates, and as the last working to be abandoned affords the most continuous view of the component beds of the Great Oolite that there is for many miles round, it appeared desirable to record and publish a detailed account. In obtaining these details I have had the valued assistance of Mr. E. T. Paris, who has named the echinoids mentioned in the section below.

The precise position of the quarry, for which it will be probably best to retain the name of "Groves' Quarry", is two miles south-west of Shipton-under-Wychwood Church. There is a station at Shipton on the Great Western Railway line between Kingham and Oxford.

Although, following precedent, I have therefore called the quarry "Groves' Quarry", there are actually four workings at the four corners of a somewhat quadrate area, the central portion of which is occupied with vast spoil-heaps.

The south-western working was the last to be abandoned, and it was in this that the details noted below were mostly obtained.

GREAT-OOLITE SEQUENCE AT GROVES' QUARRY, MILTON, OXFORDSHIRE.

		Thickness in ft.	in.
UPPER STAGE.	1 Limestone and some marl, white, rubbly. This rubble (and that of the bed below when it comes near the surface) assumes a yellow colour, and one or the other or both (i.e. 1 and 2) constitute the cap to the section: about	3	0
	2 Limestone, white and pale-brown, finely oolitic; *Anabacia complanata* (Defr.), not uncommon; *Montlivaltia caryophyllata*, Lamx., *Montlivaltia* sp., *Thamnastræa lyelli*, E. & H., *Clypeus mülleri*, Wright, *Echinobrissus woodwardi*, Wright, *Volsella imbricata* (Sow.), and *Trigonia costata*, Sow.	3	0
	3 Marl, pale-brown, rather sandy, with brown and black pieces of lignite and occasional limestone pebbles	0	3
	4 *a*. Marl, greyish-white (clayey and darker at the top), indurated in places; *Lucina bellona*, d'Orb., and *Unicardium varicosum* (Sow.)	2	0
	4[1] *b*. Limestone, white, rubbly, non-oolitic and impersistent: in places yellow-stained. When weathered forms a conspicuous yellow wavy band at the base of Bed 4*a*; *Strophodus magnus*, Agassiz, *Thamnastræa lyelli*, E. & H., ? *Isastræa limitata* (Lamx.),[2] *Trochotoma*, *Natica*, *Terebratula maxillata* auctt., *Camptonectes rigidus* (Sow.), *Grammatodon hirsonensis* (d'Arch.), *Ostrea sowerbyi*, M. & L., *Lima cardiiformis* (Sow.), *Volsella imbricata* (Sow.): 4 to 8 inches	0	6
	5 Marl of a greenish tinge weathering white; apparently unfossiliferous. The white colour of this bed, the yellow band (4*b*), and the top darker marls (4*a*) are very conspicuous in a weathered face: about	1	0
	6 TEREBRATULA-BEDS. — *a*. Limestone, white, sparsely-oolitic, crowded with *Terebratula maxillata* auctt., in places; *Clypeus mülleri*, Wright, *Hemicidaris bravenderi*, Wright (and large detached radioles probably belonging to this species), *Acrosalenia spinosa*, Agassiz, *Echinobrissus woodwardi*, Wright, *Eryma elegans*, Oppel, *Natica*, *Nerinæa*, *Rhynchonella* sp., *Serpula tricarinata*, Sow., *Camptonectes lens* (Sow.), *C. annulatus* (Sow.), *Ceromya concentrica* (Sow.), *C. Symondsi*, M. & L., *C. undulata*, M. & L., *Gervillia* cf. *waltoni*, Lycett, *Grammatodon hirsonensis* (d'Arch.), *Lucina bellona*, d'Orb., *Ostrea costata*, Sow., *Lima cardiiformis* (Sow.), *Protocardia subtrigona* (M. & L.), *Thracia curtansata*, M. & L., and *Volsella imbricata* (Sow.)	1	4
	b. Marl, greenish, with a yellow layer at the base. In places the bed above is joined on to the bed below, and when such is the case the top portion of that bed (6*c*) becomes very fossiliferous, containing many of the fossils of the bed above (6*a*); otherwise it is rather barren: 1 to 3 inches	0	2
	c. FIRST BLOCK BED.—Limestone, white, sparsely but coarsely-oolitic, massive, weathering into blocks; *Clypeus mülleri*, Wright (common), *Rhynchonella* sp. (same form as in 6*a*)	1	6
	7 Marl, greenish-grey in the upper two-thirds, becoming browner in the lower third, with a general tendency to weather white: apparently rather barren of fossils	2	6

[1] From beds 4, 5, or 6 come some peculiar little objects that somewhat resemble crinoid-ossicles. Mr. W. D. Lang informs me, however, that they are concretions, "and similar ones are common in the chalk. Stripes on the sides are said to be slickenside structure, and the whole comparable with cone in cone structure."

[2] In this paper, when a query precedes the generic name, it indicates doubt about the genus having been accurately diagnosed.

		Thickness in ft.	in.
	a. Limestone, white, sparsely-oolitic, comparatively barren, and forming a cap to the limestone below (8*c*); *Nerinæa* sp., *Terebratula maxillata* auctt.: about	0	9
8	*b.* Marl, greenish, often wanting: 0 to 4 inches	0	2
	c. Second Block Bed.—Limestone, massive, weathering into blocks, whitish, crystalline-hearted, not usually very fossiliferous; *Gervillia* cf. *waltoni*, Lycett, *Terebratula* sp.	2	0
9	Marl, brown, clayey, with a greenish-grey zone at the centre and rubbly limestone in the lower portion; radioles of *Hemicidaris bravenderi*, Wright (common), *Ostrea sowerbyi*, M. & L., and *Serpula*: about	1	0
10	Third Block Bed.—Limestone, not so prominent, dirty greenish-grey and brown, with white shell-fragments	1	0
	a. Marl, brown, with comminuted shells passing down into brown and grey-blotched, sandy, clayey marl, with occasional thin limestone-layers towards the base	1	0
11	*b.* Clay-band, dark, the black colour being due to plant-remains	0	1
	c. Marl, greenish-grey, sandy, with plant-remains common. (In the south-eastern working this is the clay that appears dark.) Passes down into	0	7
	a. Limestone, greenish-grey, sandy, with an even upper surface; vertical plant-remains, the cavities where they have been weathering so as to resemble borings	0	8
12	*b.* Fourth Block Bed.—Limestone, hard, massive, greenish-grey, weathering white and into large blocks, but internally extremely hard and somewhat resembling Carboniferous Limestone	2	0
13	Clay, pale greenish-grey, sandy, marly	1	6
14	Limestone, yellowish-brown and greenish, sandy, with well-spaced yellow oolite-granules. Sometimes a regular bed, but difficult to measure, practically disappearing in the south-eastern working	1	10
	a. Marl, brownish-green, often indurated to form an impure rubbly oolitic limestone, with conspicuous white oolite-granules, passing down into	1	6
	b. A conspicuous blue shaly clay[1]; *Placunopsis socialis*, M. & L., *Ostrea sowerbyi*, M. & L., *Rhynchonella* sp.: 4 to 10 inches.	0	7
15	*c.* Clay, brownish-green, marly, with occasional irregular seams of brown oolitic marl or limestone, with the same species of fossils as in 15*b*; and this into	0	8
	d. Upper Ostrea-Bed.—Marl, brown, clayey, indurated, oolitic; crowded with *Ostrea sowerbyi*, M. & L.	1	3
	The last layer (15*d*) *is intimately associated with the top portion of the bed below, which is:—*		
	a. Limestone, rubbly, oolitic, passing down into more compact, flaggy, coarsely-oolitic limestone, the weathered surfaces of the slabs of which exhibit innumerable small Gastropods, etc.; *Pygurus* sp.	2	8
16	*b.* Thin courses of oolitic limestone and shaly marl, softer than the overlying limestone, with a hard band of very oolitic limestone at the base. This bottom band has large white oolite-granules, and is very shelly; *Isocrinus*-ossicles, echinoid-radioles, *Pseudomonotis echinata* (Sow.)	2	8
	a. Pale-yellow oolitic marl and rubble: 1 ft. 6 in. to	2	0
17	*b.* Lower Ostrea-Bed.—Deposit of pale-yellow and yellowish marl, enclosing an extraordinary number of oysters and *Rhynchonellæ*. Most of the oysters have *Serpulæ*, polyzoans, and occasional specimens of *Webbina* on them, and are frequently pierced by the boring sponge *Talpina*, thus showing that the deposit in which they occur was of slow formation	2	8

Upper Stage.

[1] Absent as such from the south-eastern working, where bed 15*c* is thicker, tolerably conspicuous, and more of a limestone.

			Thickness in ft.	in.
Lower Stage.	18	*a.* Limestone, well-oolitic, with coarser oolite-granules and shell-debris; often obliquely stratified. Splits up at the top, and greenish shaly marl is intercalated; *Ostrea sowerbyi*, M. & L.	2	6
		b. Green and brown shale in alternating layers; lignite . .	0	6
	19	*a.* Limestone, in three beds, oolitic and shelly in places; *Ostrea*	2	0
		b. Rubble and marl with *Ostrea* (common); radioles: 1 to 4 in.	0	2
		c. Limestone, massive, shelly, oolitic. Top somewhat waterworn and in uppermost 2 inches *Chlamys vagans* (Sow.) is not uncommon: seen	3	0
			50	0

South-Western Working.—This working, as already mentioned, was where the stone was last worked, and where the succession of beds from sixteen upwards was noted. The blocks that are lying about, and are so full of specimens of *Terebratulæ*, will be readily-recognized as having come from bed 6.

It will be unnecessary to say anything more about this working, as the record given above is so full.

South-Eastern Working.—In the eastern face of this working, which is the more weathered of the two, and therefore that in which the hard bands stand out in greatest relief, the principal beds that can be readily found are the disturbed top-limestones (beds 1 and 2); the rather greenish[1] marl (4*a*) with a yellow band (4*b*) at the base; the white marl (5); and then the four great block beds (6*c*, 8*c*, 10, 12*b*), of which the upper two are the most massive. The third and fourth block-beds down, when traced along the southern face of the working, become relatively inconspicuous. In the eastern face, *below* the fourth block-bed, come marls (13 and 15*a*) with a median, rather impersistent limestone (14), and then rubbly limestone (15*c*) at the very base. This rubbly limestone, when followed along the southern face, is seen immediately above the Upper *Ostrea*-Bed, which—with the Lower *Ostrea*-Bed—will form a quick means of locating the minor divisions that have been made in the lower portion of the section. It should be particularly noticed that the blue marl (15*b*) is absent as such from this working.

It is in this working that the Lower *Ostrea*-Bed is best developed and most conveniently investigated.

North-Eastern Working.—In this working—now long abandoned—the highest beds seen are those in the eastern face. The two limestones are the two top block-beds, and the second one is the top-limestone of the western face. Here, the third block-bed is poorly-developed; but the fourth is more conspicuous and has underneath it greenish marl—bed 13. The Upper *Ostrea*-Bed can be located above bed 16*a*, which is the limestone protruding at the bottom of the working.

Western Working.—This working runs below and parallel to the road. The top conspicuous limestone is the lowest block-bed (12*b*), and the green marl immediately below it is as conspicuous as ever. The Upper *Ostrea*-Bed is the next easily-found horizon. Below it is the limestone (16*a*) and the softer marls, which form the lower portion

[1] Looks greenish, but upon closer inspection is better described as 'greyish-white'.

(*b*) of bed 16; but both divisions (that is, *a* and *b*) are much thinner here. Below, again, is the greenish marl that occurs on top of the Lower *Ostrea*-Bed; while at the base of all is seen the top portion of the yellower freestone-beds, which are seen to a greater depth in a small opening to the north, nearer the cottages.

Previous Literature.—Professor E. Hull was the first to publish any remarks upon the Milton section. He wrote—[1]

"On Milton field, in a large quarry, a section similar to that at Windrush is exhibited. There we find about 17 feet of interstratified marls, shales, and thin-bedded limestones, highly fossiliferous, resting on thick-bedded oolite more than 12 feet thick, and yielding large blocks, the one belonging to the upper zone, the other to the lower."

The "thick-bedded oolite" is numbered 18 and 19 in my section.

The late R. F. Tomes visited Milton with a view to seeing if there were any corals there.[2] He found one bed (number 4 of his record) sufficiently rich in them to cause him to name it the 'Coral-Bed'; but apparently he obtained nothing worth keeping or identifiable therefrom, because all the corals he lists came from a bed lower down—his bed 6. Mr. Paris and I found corals in beds 2, 4*b*, and 6 of the record given above. Tomes also gives a record of the beds exposed at the time of this visit to show the positions of the coralliferous limestones; but whilst it is obvious that his beds 17 and 19, or at least the portions of them that contain oysters in abundance, correspond to my beds 15 and 17 respectively, it is not so easy to say more than that his bed 6, that is, "stone in large blocks," appears to be my bed 6*c*.

Mr. H. B. Woodward, the next author to notice this section, also appears to have encountered some difficulty in making out Tomes's section, for he came to the conclusion that the topmost five beds of Tomes's record "were not clearly exhibited at the time he visited the quarry". He therefore repeated Tomes's observations so far as those beds were concerned. After that he found it necessary to make his own section, which differs materially from Tomes's.

When Mr. Paris and I visited Milton there were no quarrymen about so we were unable to check our identification of the 'small land-stones' with bed 6*a* of the present record; of the 'Blue Rag' with bed 12*b*; and of the 'Bastard White Rags' with bed 14. But I think the identifications are correct, and this being so there is a noticeable correspondence between my record and Mr. Woodward's down to bed 15*d*, which is his "brown clay with *Ostrea sowerbyi* and *Rhynchonella concinna* (abundant)". But then there is a difference. Bed 15*d* is my Upper *Ostrea*-Bed, and it occurs at 7 ft. 4 in. above the Lower *Ostrea*-Bed. Above the Upper *Ostrea*-Bed is a conspicuous blue shaly clay (15*b*). Mr. Woodward notes above his "brown clay with *Ostrea sowerbyi*, etc.", "blue clay." So I think that Mr. Woodward's Oyster-Bed is really the Upper *Ostrea*-Bed, and that in going from one working to the other to complete the downward succession he may have overlooked the fact—as could easily be done—

[1] Mem. Geol. Surv.: "The Geology of the Country around Cheltenham," 1857, p. 58.

[2] Quart. Journ. Geol. Soc., vol. xli, p. 171, 1885.

that there were *two* such beds, and therefore identified the Upper *Ostrea*-Bed of one working with the Lower of the other.

As regards the Freestone-Beds, there is general agreement between the present record and that given by Mr. Woodward.[1]

In 1906 the Cotteswold Naturalists' Field Club saw Groves' Quarry, and it was remarked that the beds were less massive than those of the Great Oolite that were quarried in the neighbourhood of Bath.[2]

It is not purposed attempting any detailed correlations of the beds in this section with those elsewhere. The time is not ripe; but it may be as well to draw particular attention to the following points:—

(1) The somewhat abundant occurrence of specimens of *Anabacia complanata* (Defrance) in bed 2, and the presence of the echinoids, *Echinobrissus woodwardi*, Wr., and *Clypeus mülleri*, Wr.

(2) The very fossiliferous nature of bed 6, all the fossils being noteworthy for correlation-purposes.

(3) The relative barrenness of the marl-beds associated with the fossiliferous top-limestones.

(4) The distinctive lithic structure of bed 14 and its richness in specimens of *Cypricardia* spp. and *Volsella imbricata* (Sow.), and to a less extent in certain other Lamellibranchs.

(5) The not infrequent occurrence of *Placunopsis socialis*, M. & L., in bed 15*b*.

(6) The occurrence of *two* conspicuous *Ostrea*-Beds (15*d* and 17), 7 ft. 4 in. apart. The oysters in the lower bed are usually encrusted with *Serpula tricarinata*, Sow., *Berenicea* spp., occasionally with *Webbina*, and are frequently pierced by the boring sponge *Talpina*.

IV.—The Post-Pleistocene Flora and Fauna of Central England.

By A. R. Horwood,

Leicester Museum.

THE central position of Leicestershire gives it not only a peculiar relationship in regard to river-drainage, streams radiating from its plateau-frontier on the one hand to the north, flowing into the Humber, and on the other to the south into the Bristol Channel, separated alone by a now comparatively insignificant divide in the neighbourhood of Lutterworth. Also the very fact that this divide is given, by the otherwise lowland character of the tract to the north and south, a barrier-like aspect, renders it highly probable that the flora and fauna in this basin-like area is more or less homogeneous. That it has been uniform in character, no doubt from pre-Glacial times, when doubtless the existing drainage systems (though probably still more ancient fundamentally) received their most recent stamp, having been little modified (except in depth or width) during Glacial or later times. For this purpose we must needs summarize all that is known as to the occurrence of plants or land and freshwater Mollusca in post-Pleistocene alluvial deposits.

[1] *The Jurassic Rocks of Britain—The Lower Oolitic Rocks of England (Yorkshire excepted)*, vol. iv (1894), p. 307.

[2] Proc. Cotteswold Nat. F.C., vol. xvi, pt. i, p. 32, 1907; see also *Geology in the Field* (Jubilee vol. of the Geol. Assoc.), pt. 2, p. 356, January, 1910.

Soar Valley.

In the county of Leicester itself no adequate account of any post-Pleistocene remains other than mammalia[1] has been published. The first notice is the result of a natural history competition which was carried on for some years before the present Museum had assumed any important position. Mr. F. T. Mott[2] reported the discovery of shells of the genera *Limnæa*, *Succinea*, etc., in gravel at Belgrave,[3] stained with iron-oxide. This gravel is doubtless part of the alluvial sand and gravel which covers the lower part of the Soar Valley. This locality is north of the town. Somewhat to the south another locality, Aylestone (excavations for gasworks),[4] has afforded more abundant evidence of a flora and fauna similar to the existing one. Here in the Soar Valley the following section was exposed:—

	ft.	in.
1. Materials of a cart road	0	6
2. Rough gravel (perhaps foundation of a road)	1	0
3. Fine grey clay	5	0
4. Black peat	1	6
5. Soft white calcareous marl	2	0
6. Red marl in situ.		
	10	0

The lowest bed (5) was said to consist largely of *Chara*, and amongst the calcareous remains of the plant and seeds were numbers of fresh-water shells, *Limnæa*, *Planorbis*, *Pisidium*, *Cypris*, and other animal remains.

The following is a list of the specimens found which passed into the hands of the late Mr. J. Plant, who gave them to the Museum:—

Plantæ.
Chara vulgaris.
cf. *Potamogeton zosteræfolius.*

Annelida.
Tubes.

Crustacea.
cf. *Candona candida.*

Gasteropoda.
Hyalinia cellaria.
H. pura.
Helix pulchella.
H. hispida.
Cochlicopa lubrica.
Pupa muscorum.
Succinea putris.
Ancylus fluviatilis.
Limnæa peregra.
L. peregra, var. *ovata.*
L. auricularia.
L. truncatula.
Bythinia leachii.
Planorbis nautileus.
P. fontanus.
P. spirorbis.
P. parvus.
P. umbilicatus.
Valvata piscinalis.

Lamellibranchiata.
Sphærium corneum.
Pisidium amnicum.

A single worn fragment of *Ostrea edulis* was amongst these otherwise lacustrine forms. The section was first noticed by the late Mr. W. J. Harrison, F.G.S., a former Curator. The deposits are

[1] A list of these up to 1889 was given in *The Vertebrate Animals of Leicestershire and Rutland*. It was summarized recently in the "Victoria County History" by Mr. R. Lydekker. Many additions must, however, be made to both.

[2] Report Leic. Lit. and Phil. Soc., 1875, p. 42.

[3] Mr. J. Plant found Rhinoceros teeth with *Succinea*, *Limnæa*, etc., in the Abbey Park Road, a little north of the south end.

[4] Ibid., 1878, pp. 26–8.

distinctly alluvial. The site was about 100 feet at most from the River Soar. At a depth of 11 feet and below Boulder-clay resting on Red Marl an antler of *Rangifer tarandus* was found close to the same spot. In the river gravels and alluvium at various points in the Soar Valley the following mammalia have been found, at the Abbey Meadow, Belgrave, Humberstone, Thurmaston, Aylestone, Barrow-on-Soar, Loughborough, Kegworth, Syston, Thurnby, Melton Mowbray, and elsewhere:—

Bison bonasus, var. *priscus*.
Bos taurus, var. *primigenius*.
Cervus elaphus.
Elephas antiquus.
Elephas primigenius.
Rangifer tarandus.
Rhinoceros leptorhinus.

Whilst the foregoing may be Glacial, the following are of more recent date:—

Bos taurus, var. *longifrons*.
Capra or *Ovis* sp.
Capreolus caprea.
Cervus dama.
Cervus elaphus.
Equus caballus.
Sus scrofa.

As to molluscan remains in Glacial beds themselves Messrs. G. W. Lamplugh and C. Fox-Strangways are said to have found *Tellina balthica* at Beasley's Sandpit, Aylestone, in the Quartzose Sand, but M. Browne[1] threw discredit on the discovery. We must say that there is no reason to doubt their occurrence, and we have found shell fragments there and elsewhere, though too fragmentary—as most Glacial contemporaneous fossils are—to determine.

Lower Trent Valley.

Passing to the north-west corner of Leicestershire and the Trent Valley, we find evidence of a similar flora and fauna in the Burton-on-Trent district. Here at Stapenhill alluvial deposits occur 17 feet above the Trent, and Mr. W. Molyneux, F.G.S.,[2] gave the following section:—

		ft.	in.
1.	Red clay	4	0
2.	Stiff yellow clay	0	6
3.	Black and yellow clay, gradually passing into a strong unctuous clay	1	3
4.	Peat containing shells and thickly charged with small crystals of sulphate of lime	1–3	0
5.	Strong yellowish-brown clay, the upper part thickly charged with shells	4	0
6.	Band of coarse gravel	0	3
7.	Hard consolidated, stratified sand, with few pebbles	2	0
8.	Loose current-bedded white and yellow sand, intersected by thin bands of peat, clay, and pebbles, and frequently containing lumps of coal and black shale	10	0
9.	Coarse white and yellow clayey gravel containing bones of animals		
		23–5	0

[1] Trans. Leic. Lit. and Phil. Soc., 1901, p. 30.
[2] *Burton-on-Trent, its History, its Waters, and its Breweries*, 1869, p. 182.

R. Garner, author of the *Natural History of Staffordshire*, identified in bed 5 the following shells:—

Helix pulchella.	*Vertigo* sp.
H. rotundata.	*Succinea oblonga.*
H. fulva.	*Planorbis* sp.
Bulimimus obscurus.	*Limnæa peregra.*
B. sp.	*L. truncatula.*
Vertigo substriata.	

In addition to these a diatom, *Fragillaria*, was detected, and the wing of an insect, the elytron of a beetle, etc., but not in the peat with the shells. In a field south of this section another was seen—

1. Brown clay	6 inches to 2 feet.
2. Dark earthy sand	1 foot.
3. Coarse ochreous gravel	1 to 2 feet.
4. Current-bedded sand with veins of clay	4 to 6 feet.
	6 ft. 6 in. to 11 feet.

In bed 4 roots of aquatic plants, probably *Iris*, were found, passing up through the gravel above, becoming ochreous in colour. The claw of a cray-fish, *Astacus fluviatilis*, was found in the gravel. At Stretton, on the opposite or north side of the river, the section is—

	ft.	in.
1. Strong red clay and gravel	10	0
2. Yellow gravel and sandy clay	5	0
3. Yellow sand and gravel	1	0
4. Blue clay and gravel passing into strong clay, the upper surface containing a band of from 2 to 3 inches of black peaty matter	2	0
5. Coarse yellow gravel	0	9
6. White and yellow sand and clayey gravel, with subangular flints	3	0
7. Strong red marly clay and gravel	2	0
8. Tenacious dark-blue clay	2	3
9. Deep yellow ochreous sand	0	3
10. Strong white clayey gravel, bottom not seen	4	0
11. Blue and brown clays	–	–
	30	3

In No. 4 fragments of wood and plants have been found and aquatic plants in No. 8. In No. 4 very large blue and yellow flints derived from the Drift occur.

In the river-gravels at Andersley, at 3–5 feet deep, roots and branches of trees occur, and at a lower level also, in addition, hazel-nuts, aquatic shells, and bones of mammalia. Professor Boyd Dawkins identified the latter as bones, jaws, and teeth of *Sus scrofa*, *Bos longifrons*, and domestic varieties, *Equus*, and bones of wolf or dog, while similar remains have been found at Burton itself, near Whitehead's Brewery, Mosley Street old river-course, sewer excavations at Anderstaff Lane, and at Stretton. At the Hay, below 3 ft. 6 in. of sand and gravel, in stiff blue and yellow clay, roots and branches of trees and other plants were found, and below the latter peat (1 ft. 9 in.). At Mosley Street, below 5 feet of clay, 8 feet of peat was met with.

Below this last horizon, in black consolidated gravel (8 feet thick), Edwin Brown found—

CRUSTACEA.
Daphnia.

GASTEROPODA.
Vertigo.
Cochlicopa lubrica.
Succinea putris.
Planorbis albus.
P. spirorbis.
Planorbis contortus.
Physa fontinalis.
Limnæa peregra.
L. palustris.
L. stagnalis.
Bythinia tentaculata.

LAMELLIBRANCHIATA.
Sphærium corneum.

Most of these too were found at Hay, Mosley Street, and in excavations for sewage tanks at Stretton. Compared with those found in the peats and clays at Stapenhill on the other side there is a difference in species. At Barton Station, south of Burton, roots of plants and branches of trees were met with, and containing an admixture occasionally of peat, 2 feet in thickness, below 6 ft. 2 in. of clay, sand, and gravel.[1] The latter were impregnated with carbonate of iron and manganese, containing much vegetable matter. In forming No. 3 tank at Stretton the following section was uncovered:—

1.	Yellow clay	1 foot.
2.	Blue clay, containing plants	6 inches.
3.	Peat	3 feet.
4.	Shell marl, with bones, jaw, teeth (*Bos longifrons*)	1 to 8 feet.
5.	Gravel with flints, bottom not seen	3 feet.
		8ft. 6in. to 15ft. 6in.

The deposits were very variable, the shell marl full of shells, irregular, sometimes lying on gravel, sometimes on peat, or dark clay with aquatic shells. Plant roots penetrate from the peat through the shell marl into the gravel. In the blue clay matted masses of aquatic plants occur coated with phosphate of iron. Dr. H. T. Brown, F.R.S.,[2] gives the following section at the Sewage Works near Stretton (140 O.D.):—

		ft.	in.
1.	Soil, subsoil, and sand	3	0
2.	Sandy clay	0	5
3.	Red sand	1	4
4.	Thin bed of peat	0	2
5.	Sand stained with peat	1	0
6.	Dark peaty clay, more peaty below	2	4
7.	Peat, with sedges and hazel-nuts	1	11
8.	Irregular bed of sand, coloured by peat, with a thin, irregular bed of gravel (1 to 2 inches), in other places a highly calcareous shell marl	1	0
9.	Very thin beds of interstratified clay and sand	3	0
10.	Gravel	5	0
	Marl below.		
		19	2

[1] About 30 feet below the surface in the gravels a deer's horn was found.

[2] Vide *The Geology of the Country between Derby, Burton-on-Trent, and Loughborough*, 1905, p. 64.

About 30 yards west the gravel is 3 feet nearer the surface. The fauna was as follows:—

CRUSTACEA.
Cypris.

GASTEROPODA.
Segmentina nitida.[1]
Planorbis parvus.
P. contortus.
Physa fontinalis.
Amphipeplea glutinosa.[2]
Limnæa auricularia.
L. stagnalis.
L. peregra.
Velletia lacustris.
Bythinia tentaculata.
Valvata piscinalis.

In a trench cut at Hay, peat, 6 to 9 inches thick, was found with hazel-nuts at the bottom, at a depth of 6 ft. 7 in.; and at Annesley Meadow at a depth of 2 ft. 7 in. in stiff clay, with a layer of vegetable mould 7 inches above; and in another section south-east of a large well belonging to Messrs. Bass, 45 yards from the River Trent, there was a layer of vegetable mould 6 inches thick succeeded by clay, with some peaty matter (4 feet) changing into gravel coloured by peat, the peaty clay thickening towards the river.

DERWENT VALLEY.

The lacustrine clay of Sinfin Moor is shown in the following section:—

	ft.	in.
1. Black peat	1	2
2. Disintegrated shells	0	3
3. Stiff yellow clay	2	0
4. Shells	2	0
5. Quicksand	3	0
	8	5

In the Erewash Valley the following plants, Crustacea, shells, etc., have been found and identified by Mr. Clement Reid, to whom the writer is indebted for assistance in the readiness with which he has been supplied with literature on this subject:—

PLANTÆ.
Lycopod spores.
Scirpus lacustris.

CRUSTACEA.
Daphnia.

INSECTA.
Chrysalis cases.

GASTEROPODA.
Limnæa peregra.
Bythinia tentaculata.
Valvata piscinalis.
Viviparus sp.

LAMELLIBRANCHIATA.
Sphærium corneum.

At Allenton, near Derby, also in the Derwent Valley, Mr. Arnold Bemrose[3] found the following plants, with *Hippopotamus*, *Elephas*, *Rhinoceros*:—

Ranunculus aquatilis.
R. sceleratus.
R. flammula.
R. repens.
R. ? *bulbosus.*
R. sardous.
Viola palustris.
Montia fontana.
Rubus idæus.
Potentilla sp.

[1] Found in E. and W. Norfolk, Cambridge, Worcester, Montgomery, N. Lines, S. and W. Lanes.

[2] The nearest counties where this is now found are: Kent, Berks, Bucks, E. Suffolk, E. Nortolk, Huntingdon, N.E. and S.E. York, N. Lincoln, Huntingdon.

[3] Quart. Journ. Geol. Soc., vol. lii, pp. 497-500, 1896.

Hydrocotyle vulgaris.
Valeriana officinalis.
Eupatorium cannabinum.
Leontodon autumnalis.
Taraxacum officinale.
Ajuga reptans.
Atriplex.
Eleocharis palustris.
Scirpus pauciflorus.
Carex.
Isoetes lacustris.

According to Mr. Reid this flora is Interglacial, and it is undoubtedly Pleistocene, judging from the associated mammals, but we include it for comparison with the later floras.

Higher Trent Valley.

In the higher reaches of the River Trent, in alluvium of the tributary Cocker Beck, the following mammalia were recognized by E. T. Newton[1]:—

Human femur.
Horse.
Ox (? *Bos longifrons*).
Sheep or goat.
Pig.
Dog or wolf.

Mr. Clement Reid recognized in the silt the following plants:—

Ranunculus aquatilis.
R. flammula.
R. acris.
Fumaria officinalis.
Arenaria trinervia.
Spergula arvensis.
Montia fontana.
Prunus spinosa.
P. padus.
Rubus.
Potentilla tormentilla.
Apium graveolens.
A. nodiflorum.
Cornus sanguinea.
Sambucus nigra.
Carduus palustris.
Solanum dulcamara.
Mentha aquatica.
Galeopsis tetrahit.
Stachys sylvatica.
Chenopodium rubrum.
Rumex conglomeratus.
Urtica dioica.
Corylus avellana.
Scirpus lacustris.
Carex spp.

The following shells were also found:—

Pisidium pusillum.
Sphærium sp.
Acanthinula lamellata.
Carychium minimum.
Clausilia cf. *rugosa.*
C. sp.
Cochlicopa lubrica.
Helix hortensis.
H. lapicida.
H. nemoralis.
H. pulchella.
Limnæa cf. *peregra.*
L. truncatula.
Physa hypnorum.
Planorbis nitidus.
P. spirorbis.
Pupa anglica.
P. cylindracea.
Pyramidula rotundata.
Succinea elegans.
S. putris.
Vertigo alpestris.
V. antivertigo.
V. pusilla.
Vitrea cellaria.

Peat and vegetable matter were noticed in sewer cuttings at old Basford in the Leen Valley; and in peat at Old Radford, *Quercus robur* and *Pinus sylvestris* were observed by Mr. Shipman. At Clifton two teeth of *Elephas primigenius* were discovered 6 feet deep in brick-earth, and at Sneinton, close to Nottingham, a band of peat (12 to 18 inches) was found by Mr. Shipman, containing hazel-nuts and *Bos longifrons*.

[1] *The Geology of the Country between Newark and Nottingham* (Mem. Geol. Surv.), 1908, p. 86.

South of the Trent the Thirlbeck River alluvium has yielded—

Bythinia leachii.
B. tentaculata.
Hygromia hispida.
Limnæa peregra.
Planorbis complanatus.
Planorbis marginatus.
Sphærium corneum.
S. rivicola.
Unio sp.

The Car Dyke alluvium also afforded—

Bythinia tentaculata.
Helix nemoralis.
Hygromia hispida.
Limnæa peregra.
Planorbis marginatus.
P. spirorbis.
Sphærium corneum.

At Edwalton the following were found:—

Bythinia tentaculata.
Clausilia cf. *rugosa.*
Limnæa palustris.
L. peregra.
Planorbis marginatus.
Pyramidula rotundata.
Vitrea cellaria.

Vale of Belvoir.

The alluvium of the River Devon contains the following shells:—

Bythinia tentaculata.
Hygromia hispida.
Limnæa palustris.
L. peregra.
Neritina sp.
Valvata piscinalis.
Unio cf. *pictorum.*

In the late glacial deposits at Kirby Park the tooth of a mammoth was found, which is now in the Woodwardian Museum, and was figured by Leith Adams ("The Brit. Foss. Elephants": Pal. Soc., 1879, pl. xiii).

At Hose[1] in brown loam freshwater shells are found in the Smite Valley.

In Barnes' brickyard north of Melton in the Eye Valley, at a depth of 9 feet in sand, boles and roots of trees, with bark and hazel-nuts, occur. Mammalian bones occur in gravel below this, including a human cranium, and bones and antlers of the red deer.

Valley of River Welland.

The deposits differentiated in the area covered by old Sheet 64 were grouped by Professor J. W. Judd[2] as follows:—

Post-Glacial.
1. Marine alluvium, warp of Fens.
2. Alluvium of present rivers.
3. Alluvium of old fen lakes.
4. Peat interstratified with marine silt.
5. Marine gravels of Fenland.
6. Estuarine gravels.
7. Low-level valley gravels.
8. High-level valley gravels.
9. Cave deposits.

He defined the glacial beds as—

1. Glacial or Boulder-clay.
2. Gravels.
3. Sands.

[1] *The Geology of the Melton Mowbray District and South-East Nottinghamshire* (Mem. Geol. Surv.), 1909, p. 89.
[2] *Geology of Rutland*, 1875, p. 56.

But he admitted this was only a provisional arrangement, and much subsequent subdivision has been made.[1]

He classed as pre-Glacial the following:—

1. Pebbly gravels and sands.
2. Brick-earths.
3. River gravels.
4. Lacustrine deposits.

In referring to the deposits mentioned below as pre-Glacial at Casewick, Mr. Clement Reid indeed regards them as Neolithic, but they may be, he says, "of older date." He records *Nuphar luteum*, *Galium aparine*, *Atriplex patula*, *Rumex crispus*, in addition to those given below. But we only here need consider those deposits in which land or freshwater mollusca occur, so that these modifications do not affect the case, for it is rarely that any molluscan remains are found in the Boulder-clay itself in the Midland area,[2] whilst the few instances of marine shells in the pre-Interglacial or post-Glacial beds are mentioned only to indicate where lacustrine and marine conditions alternated.

It is in the lacustrine deposits alone that plants and shells have been found in the above area. Thus Professor Morris[3] discovered a freshwater deposit at Casewick in a hollow of the Kellaways rock covered in turn by glacial beds. The section was—

	ft.	in.
1. Gravel and sand in wavy seams	7–8	0
2. Sand and gravel, with *Belemnites*, *Gryphæa*, etc.	3	0
3. Freshwater deposit, grey, sandy clay	2	0
4. Freshwater deposit, brown, sandy clay and veins of gravel	1	6
5. Freshwater deposit, peaty clay with plants and shells	1	6
6. Freshwater deposit, dark sandy clay with plants and shells, with pebbles of chalk and flint and fragments of northern clay drift, the base being extremely irregular	3	0
	18–19	0

The plants, Crustacea, etc., were as follows:—

PLANTÆ.
Ceratophyllum demersum.
Equisetum.

CRUSTACEA.
Candona ? lucens (juv.).
C. reptans.
Cypris (small species).

GASTEROPODA.
Helix aculeata.
H. pulchella.
H. hispida.
Succinea putris.
Carychium minimum.
Planorbis carinatus.
P. umbilicatus.
Limnæa peregra.
Ancylus fluviatilis.
Velletia lacustris.
Bythinia tentaculata.
Valvata piscinalis.
V. cristata.

LAMELLIBRANCHIATA.
Sphærium corneum.
Pisidium amnicum.
P. amnicum, var. *pulchella.*
P. pusillum.
P. pusillum, var. *obtusalis.*

[1] R. M. Deeley, Quart. Journ. Geol. Soc., vol. xlii, p. 437, 1886.

[2] At Beasley's Pit, Aylestone, Mr. G. W. Lamplugh and the late C. Fox Strangways found *Tellina balthica*.

[3] Quart. Journ. Geol. Soc., vol. ix, p. 321, fig. 2, 1853.

In addition to these contemporary species were derived fossils from the Oxford Clay—

Cerithium.
Area.
Belemnites.
Echinus.
Other marine remains.

A comparison between the proportional number and the species represented in these pre-Glacial deposits and those found in the post-Glacial beds shows how very similar in species and general character the periods preceding and following the Glacial Period were. If we regard these pre-Glacial beds as really mid-Glacial or Interglacial the comparison is equally interesting.

Another bed 3 miles to the west in the River Gwash Valley contains land shells and bones, being possibly slightly later. In the deposits actually assigned to the Glacial epoch no contemporary molluscan remains were noticed by Professor Judd.

Passing to the post-Glacial deposits, with which we are more directly concerned, the only cave deposits are those at Tinkler's Quarry, Stamford. Professor Rolleston identified the following:—

Hyæna (teeth).
Elephas (tooth).
Cervus megaceros (tooth).
Cervidæ, various.

This cave was said to have been 15 to 20 feet square, and was doubtless a hyæna cave to which prey had been conveyed. The long bones were broken and some had been gnawed.

In the overlying valley gravels, locally in thin sandy loam, molluscan remains occur, but are not common, whereas mammalian remains are, including living and extinct types intermingled, as *Elephas*, rhinoceros, hippopotamus, hyæna, horse, red deer, and urus. No flint implements had been found at the time in these gravels. Above these a loam, like the loess, containing remains of living terrestrial shells, occurs near Peterborough. Mammalian remains occur in gravel at Helpston, including the Mammoth.

In the estuarine gravels both freshwater and marine shells occur at Peterborough, and at Overton Waterville the following: *Ostrea edulis*, *Cardium edule*, and the land and freshwater species *Planorbis carinatus*, *Limnæa glutinosa*, *Ancylus fluviatilis*, *Bythinia tentaculata*, *Pisidium amnicum*. The following mammalian remains were associated with them: *Elephas primigenius*, *Rhinoceros tichorhinus*, *Equus caballus*, *Canis lupus*, *Hyæna spelæa*, *Cervus elaphus*, *Bos primigenius*.

Limnæa (*Amphipeplea*) *glutinosa*, an extremely local species, is still found in South Lincolnshire and in Northampton, East Norfolk, Bucks, Berks, and East Kent, but is otherwise rare.

In the marine gravels of the Fenland the fauna includes mollusca and mammalia, viz.: *Littorina littorea*, *Turritella communis*, *Buccinum undatum*, *Tellina solidula*, *Ostrea edulis*, *Mytilus edulis*, *Cardium edule*, *Cyprina islandica*. This last, though now rare, is still found in the North Sea. The peat, and marine silt which is interstratified with it, contains a diversified flora and fauna. In the peat, made up largely of *Sphagnum* and other bog-mosses, stools of trees are found, e.g. oak, birch, etc. These are often found washed out and waterlogged along the Lincolnshire coast. Of mammals the following occur: *Bos primigenius*, var. *longifrons*, Irish elk, wild boar, red deer, bear, otter,

beaver, wolf, fox. In the buttery clay marine shells occur, viz.: *Ostrea edulis*, *Cardium edule*, *Scrobicularia piperata*. Foraminifera have also been found, and remains of marine mammals, whale, and seal are not uncommon.

In the alluvium of the Old Fen lakes or meres of Whittlesea, Ramsey, Ugg, etc., the alluvium or silt is crowded with *Unio*, *Anodon*, *Paludina*, *Planorbis*, *Limnæa*, forming a shell marl. The alluvium of the present rivers contains also a considerable flora and fauna, and consists of black loam or silt, reformed by modern rivers, and continually being augmented year by year. In the Nene and Welland valleys these are very extensive. In the Fens the marine alluvium or warp is found near Crowland, and resembles the silt found associated with peat at a lower horizon.

Valley of River Nene.

In a fissure of the Lincolnshire Oolite at Brigstock, Mr. A. Wallis found recent land and freshwater shells, and Mr. Beeby Thompson[1] explained their occurrence as due to disturbance of Lincolnshire Oolite and redeposition with introduction of the shells at the time of the latter. He suggests their pre-Glacial age, and preservation in Interglacial clay. This would lend support to the earlier age of the shells at Casewick, also in a fissure. In a later paper Mr. Beeby Thompson[2] includes these shell deposits in the late mid-Glacial gravels, which underlie the Upper or Chalky Boulder-clay.

The shells that were found were—

Succinea putris.	*Helix nemoralis* or *arbustorum.*
Cochlicopa lubrica.	*Pupa marginata.*
Helix pulchella.	*Pisidium pusillum.*

In valley gravels *Elephas antiquus*, *E. primigenius*, *Rhinoceros tichorhinus*, *R. leptorhinus*, *Hippopotamus major*, *Equus caballus*, *Bison priscus*, *Bos primigenius* are found, tusks and teeth in the upper part of the Nene Valley, lower down near Peterborough marine shells, *Cardium* and freshwater species of *Physa*, *Limnæa*, *Planorbis*. At Elton and Northampton Mammoth occurs.

In river alluvium at Martin's brickyard Mr. H. N. Dixon[3] found—

Nuphar luteum.	*Polygonum.*
Stellaria media.	*Mercurialis perennis.*
Prunus spinosa.	*Alnus.*
P. padus.	*Corylus avellana.*
Sambucus nigra.	*Quercus robur.*

Mammalia, *Bos longifrons* and *B. primigenius*, horse, sheep, wild hog, red deer, freshwater mollusca, and human remains, often coated with vivianite, also occur.

For comparison with localities farther removed from the central tract of Leicestershire, we add a list of plants, etc., found outside the midland or central tract. At Dursley, Gloucestershire, to the south-west, a calcareous tufa in process of formation is full of leaves. Miss M. A. and Mr. Clement Reid[4] found leaves of hazel, elm, and hart's tongue in it.

[1] Geol. Mag., 1895, pp. 1–3, reprint. [2] Proc. Geol. Assoc., 1910, p. 485.
[3] *The Origin of the British Flora*, Clement Reid, F.R.S., 1899, p. 13.
[4] Ibid., p. 66.

At Wolvercote, near Oxford, to the south, in an alluvial deposit lying over Palæolithic implements and bones of Bison, the following were found :—[1]

Ranunculus aquatilis.
R. sceleratus.
R. repens.
Potentilla tormentilla.
Viola.
Hippuris vulgaris.
Heracleum sphondylium.
Potamogeton.
Eleocharis palustris.
Scirpus lacustris.
Carex rostrata.

Compared with results obtained in Scotland and East Anglia, the record of life in the post-Pleistocene deposits of Central England is meagre, and shows what needs yet to be done. The survey of the localities where material has been found, in this summary, may have the desired effect of stimulating further investigation.

As regards glacial deposits, it is probable that careful examination of accumulations such as the quartzose sand with interstratified carbonaceous layers may have good results.

The occurrence of several species of living land and freshwater shells in the mid-Glacial gravels, at Brigstock and at Casewick (not certainly of this age at the last locality, but probably), lends support to the pre-Glacial origin of the prototypes of our land and freshwater mollusca. The known existence of many of the plants found with the mollusca in pre-Glacial times, e.g. *Ranunculus aquatilis, R. sceleratus, R. repens, Nuphar luteum, Stellaria media, Prunus spinosa, Heracleum sphondylium, Atriplex patula, Betula alba, Alnus glutinosa, Corylus avellana, Quercus robur, Ceratophyllum demersum, Pinus sylvestris, Alisma plantago, Eleocharis palustris, Scirpus lacustris, Isoetes lacustris,* etc., lends support to this notion. Moreover, the universal distribution of certain species of mollusca throughout this central region is also evidence of their greater antiquity, viz. :—

Hyalinia cellaria.
Helix pulchella.
H. hispida.
Cochlicopa lubrica.
Succinea putris.
Planorbis spirorbis.
P. umbilicatus.
Physa fontinalis.
Limnæa peregra.
L. auricularia.
L. stagnalis.
Ancylus fluviatilis.
Bythinia tentaculata.
Valvata piscinalis.
Sphærium corneum.

To this may be added the homogeneity, in general, of the mammalian fauna found in association with both the plants and other animals of the post-Pleistocene deposits.

V.—The Residual Earths of British Guiana commonly termed 'Laterite'.

By Professor J. B. Harrison, C.M.G., M.A., F.G.S., F.I.C., assisted by K. D. Reid, Assistant Analyst British Guiana.

(*Concluded from the November Number, p.* 495.)

The losses of their constituents during the decompositions of the rocks.—As shown in this paper the analyses of the rocks and of their decomposition-products do not indicate the extent of the degradation which

[1] *The Origin of the British Flora*, Clement Reid, F.R.S., 1899, p. 61.

Corrections made in issue of 3-1911
H.B.C.

has taken place. To ascertain this it is necessary to re-calculate the analytical figures so that their proportions are comparable to those of one of the constituents which is assumed to have remained unchanged. The structures of the Surinam and the British Guiana bauxitic laterite show clearly that, contrary to what is not unfrequently assumed, alumina cannot be regarded as a static component in rocks and their decomposition-products. It is evidently under condition of lateritization capable of entering into solution, transference from place to place, and redeposition in the form of alumina hydrate where conditions are favourable. The constituent which appears to be the most stable under conditions of weathering is titanium oxide, especially that present as ilmenite. But unfortunately as a rule it is present in such low proportions in rocks and in their residuary products that, when taken as the static constituent, errors in analysis of low value are productive of variations of wide extent in the results calculated on them.

When calculations of this sort are made on the epidiorite of Issorora and on the lateritic earth with its enclosed pisolites the difficulty arises that the iron in the earth and in its enclosed pisolites has not been derived only from the portion of the rock which has given rise to the earth, but is largely an infiltration product from other lateritic earth which has been removed by denudation.

The results calculated on titanium oxide as the static constituent are as follows:—

Table XVIII.

	Original Epidiorite.	Earth with Pisolites.
Silica	49·06	7·51
Aluminium Oxide	18·87	10·69
Iron Protoxide	6·38	
Iron Peroxide		21·26
Magnesium Oxide	10·95	·21
Calcium Oxide	11·70	·11
Sodium Oxide	·97	·02
Potassium Oxide	·06	·09
Water	·43	3·66
Titanium Oxide	·88	·88
Manganese Oxide	·34	·01
	99·64	44·44

The excess of iron, the increased amount of water, and the gain in weight of the oxidation of the protoxide of iron in the original rock being eliminated, it is seen that of 100 parts of the constituents of the epidiorite only 26·4 remain in the laterite and that therefore a loss of 73·6 per cent. of the epidiorite has taken place. This loss falls on its constituents in the following proportion shown as losses per 100 parts of each:—

Table XIX.

Silica	84·7
Aluminium	43·4
Magnesium Oxide	98·1
Calcium Oxide	99·1
Sodium Oxide	97·9
Manganese	97

Similar calculations based also on the assumption that the titanium oxide is the static constituent have been made with regard to the Tumatumari, Omai Falls, and Mazaruni laterites. Their results are given in Table XX—

TABLE XX.

	Tumatumari.		Omai Falls.		Mazaruni.	
	Diabase.	Laterite.	Diabase.	Laterite.	Hornblende Schist.	Laterite.
Silica	51·19	30·43	53·25	29·90	51·70	15·84
Aluminium Oxide	15·80	15·80	17·16	11·78	15·94	11·38
Iron Protoxide	14·28		12·53		14·40	
Iron Peroxide		6·40		14·30		2·55
Magnesium Oxide	5·63	·13	6·10	·08	5·54	·04
Calcium Oxide	9·58	·14	7·46	·07	9·60	·003
Sodium Oxide	2·09	·08	2·50	·10	1·87	·18
Potassium Oxide	·60	·12	·69	·30	·08	·16
Water	·30	6·77	·32	7·02	·30	3
Titanium Oxide	·40	·40	·32	·32	·30	·30
	99·87	60·27	100·33	63·87	99·73	33·453

Allowing for the gain in water in each of them, for the oxidation of the protoxide of iron, and for a small excess of iron peroxide due to infiltration in the Omai Falls sample, we have losses of 47·4, 44·6, and 70·5 per cent. respectively of the original rocks during their degradation to laterite. The loss per 100 parts of each constituent of them is as follows:—

TABLE XXI.

	Tumatumari.	Omai Falls.	Mazaruni.
Silica	40·5	43·6	69·3
Aluminium	nil	31·3	28·6
Iron Peroxide	58·7	nil	83·6
Magnesium Oxide	97·7	98·7	99·2
Calcium Oxide	98·5	99·1	99·9
Sodium Oxide	96·1	96	90·4
Potassium Oxide	80	47·8	nil

The range of variation in the losses of alumina and oxide of iron is wide, being for alumina from *nil* to 31·3 per cent. and for oxide of iron from *nil* to 83·6 per cent.

The most interesting points in the above results are the great loss of combined silica and the change of some of the silica set free into quartz. Thus, in the Tumatumari sample 46·01 of the combined silica present in the rock is not found in that form in the derived laterite, but 25·2 of the silica set free has been changed into quartz; in the Omai Falls sample 41·7 of the combined silica has disappeared, leaving in its place 18·2 of quartz; and in the Mazaruni sample 39·1 of the combined silica has been apparently lost from that condition, whilst only 3·2 of it remains as quartz.

The following changes are indicated as having occurred during the degradation of the granite and the hornblende-granites at Mazaruni and Mahdia:—

TABLE XXII.

	Mazaruni.		Mahdia.	
	Granite.	Pipe-clay.	Hornblende Granitite.	Pipe-clay.
Silica	73·81	49·61	68·20	29·04
Aluminium Oxide	13·93	14·47	15·83	11·30
Iron Peroxide	1·41	1·49	3·43	1·21
Magnesium Oxide	·72	·07	2·14	·18
Calcium Oxide	·88	nil	3·49	·04
Sodium Oxide	2·80	·28	3·07	nil
Potassium Oxide	4·81	·36	2·88	·18
Water	·74	6·22	·50	3·15
Titanium Oxide	·62	·62	·46	·46
	99·72	73·12	100	45·56

Allowing for the added water in each and for slight apparent increases in the alumina and iron oxide of the Mazaruni specimen, there is a loss of 33 per cent. of the constituents in the case of the granite and of 54·5 per cent. in the case of the hornblende granitite. The losses in each 100 parts of the various constituents work out as follows:—

TABLE XXIII.

	Mazaruni.	Mahdia.
Silica	32·8	57·4
Alumina	nil	28·4
Iron Oxide	nil	64·7
Magnesium Oxide	90·3	91·6
Calcium Oxide	100	98·8
Sodium Oxide	90	100
Potassium Oxide	92·5	97·2

In the cases of the conversion of the rock into pipe-clay there are apparent losses of silica present as quartz as compared with the amount calculated to be present in the granite and the hornblende-granitite. This is due to re-arrangement of the material by washing, which has separated the finer particles from the coarser ones, which, as a rule, form coarse sands to fine angular gravel on the surface of the pipe-clay.

In the foregoing description of the British Guiana lateritic earths and their components, I have confined myself to the laterites which are in situ, and have not described the so-called low-level laterite or the "Alluviale Laterit or Sekundare Laterit" of G. C. Du Bois, which he defines as "Aluminous Laterit" or as the "Alluvium von Lateritdetritus". Where I have seen alluvial deposits of this nature in British Guiana they have been mixed to such an extent with the detritus from granitic rocks or even from clastic rocks that they have

not, in my opinion, a right to the term laterite. But I have shown in connexion with certain of the laterites I have described how readily aluminous deposits can be formed from normal lateritic earths by ordinary processes of elutriation and redisposition. The accurate and complete account of the "Alluviale Laterit" of Surinam by Du Bois is fully applicable to those of British Guiana. But personally I do not apply the term laterite to these detrital deposits, which are equally well described as valley or river alluvia.

I have also not described the deepest layers of the residual deposits which are met with in the shafts of mines below the water-table and closely overlying the unaltered rock. They do not, as far as my limited experience goes, show the characteristics to any marked extent of laterite either according to Buchanan's description or to more recent views. They are best described as decomposed diabase, gabbro, or schists as the case may be, as they largely consist of partially decomposed fragments of these rocks with varying amounts of secondary quartz, hydrates of alumina and iron, and kaolinite derived in part from the decomposing rocks or washed in from overlying lateritic earths.

Where the original rocks are massive and compact, are only covered with comparatively thin layers of lateritic products, and are practically above the water-table, the transition from unaltered rock to lateritic earth is abrupt, and few, if any, particles of the original rock, except grains of ilmenite and of similar highly resistant mineral, can be found in the residual earths lying directly in the rock.

The Laterite of Surinam and of French Guiana.—The ferruginous residual earths in South America appear to have attracted the notice of geologists and mining experts in these countries from quite early periods; for example, amongst other early authors they are mentioned by J. B. Le Bland, *Description de la Guyane Française*, 1814; v. Eschwege, *Beiträge zur Gebirgskunde Brasiliens*, 1832; Schomburgk, *Reisen in Guyana und am Orinoko*, 1841; Heuser, *Beitrag zur Kenntnis des brasilianischen Küstengebirges*, 1858; Le Neve Foster, "Caratal Gold-field" (Q.J.G.S., No. 99, vol. xxv, pp. 340–2); and Tate, "Geology of Guyana Venezuela" (Q.J.G.S., No. 99, vol. xxv, pp. 349 and 350).

Among more recent works in which more or less detailed accounts of the laterites of Surinam and French Guiana are given are: Martin, *Reise nach Niederländisch-Westindien*, 1888; Levat, *Recherche et l'exploitation de l'or en Guyane Française*, 1898; Du Bois, *Geologisch-bergmännische Skizzen aus Surinam*, 1901; van Cappelle, *La constitution géologique de la Guyane hollandaise*, 1907; whilst the most complete account of the Surinam laterites is Du Bois' monograph *Beitrag zur Kenntnis der Surinamischen Laterit*, 1903, to which I have several times referred.

Unfortunately for the purposes of this paper the analyses given by the above authorities are more or less incomplete owing to the silica present in the form of quartz not having been determined separately from that present in the combined state. The analyses of "Roche à Ravet" given by Levat on p. 42 of his work show that, even if all the silica was present in the combined state, the samples from Maripa would have contained 7·6 per cent. and those from Awa

7·7 per cent. of alumina in the state of hydrate. In the majority of the analyses of concretionary ironstones given by Du Bois it is not possible to demonstrate the presence of free aluminium hydroxide, but his analyses of an alluvial one show that at least 5·2 per cent. of alumina is present in the form of hydrate.

The fact that bauxite or gibbsite is found in the laterites of Brazil and of the Guiana has been known for many years. R. Hermann, in 1869 (*Journal f. prakt. Chemie*, vol. i. p. 72), described hydrargillite which occurred in the laterite of Villa Ricca in Brazil, whilst its occurrence in French Guiana was recorded in 1878 by Jannetaz in the *Bulletin de la Société Minéralogique de France*, vol. i, p. 70. The first full description of typical bauxitic laterite from Surinam is that given by Du Bois, pp. 34–7 of his monograph on the laterite of that colony. He there gives the following 'technical' analyses:—

TABLE XXIV.

	X	XI	XII
Alumina	63·3	48·5	52·5
Iron Peroxide . . .	10·5	21·6	14·4
Silica	7	14·5	3·1
Calcium Oxide . . .	1	1	1·5
Water	17·6	14	27·6
	99·4	99·6	99·1

Du Bois specifically states that the silica is present in them in the form of secondary chalcedony. If all of it is so present the bauxite contains from 48·5 to 63·3 per cent. of free alumina or from 62·5 to 80·9 per cent. of aluminium hydrate, whilst the lowest proportion of alumina that can be present in the uncombined state on the assumption that all the silica is combined with alumina will vary from 40 to 57 per cent.

The studies which have been made in the Guianas by Du Bois, Levat, Lungwitz, van Cappelle, myself, and others, both in the field and in the laboratory, show that certain residual deposits derived mainly from rocks of the diabase-gabbro, diorite, and porphyrite types which contain predominantly felspars of the albite-anorthite series have full right to be termed laterite both in the restricted sense of the term advocated in this journal by Dr. Evans and Mr. Crook and in the wider meaning originally ascribed to it by Buchanan; that masses of bauxite occur in residual earths of complex composition which cannot be described as characteristically aluminous, as they are usually to more marked extents siliceous or ferruginous, although they invariably contain more or less hydroxide; and that the concretions in the residual earths vary from concretionary ironstones to impure ferruginous bauxite.[1]

I have only seen the laterite in one district of Surinam where it formed a covering to a greatly metamorphosed sericitic schist. Here there is a gradual change of the decomposing schist into its laterite, the change extending to considerable depths in the schist. The lateritic earth, covered in places by concretionary masses of ironstone,

[1] In the Guianas the formation of masses of bauxite appears to be due to later segregation changes in the metasomatic residual earth rather than to the completeness of the original decompositions.

reminded me of Logan's account of the ferruginous and silico-ferruginous rocks and laterite of Singapore (Q.J.G.S., vol. vii, p. 331, 1851), and of Mr. Scrivenor's description of the laterite of the Malay Peninsula (Geological Magazine, September, 1909, No. 543, p. 431).

The view that I have formed after many years' fairly intimate acquaintance with the Guiana residual deposits in the field and in the laboratory is that the terms laterite or lateritic earths are both useful and convenient ones to denote the whole mass of the residual deposits which are characterized by the occurrence in them of concretionary masses varying from highly ferruginous to highly aluminous, as well as, in places, by the presence of secondary silica in quantity. In my opinion laterite of the above nature can be accurately defined, following Du Bois (p. 3 of his monograph), as the weathering product of igneous or metamorphosed rocks in which by chemical decomposition the silicates contained in them have been changed to secondary siliceous compounds, secondary silica and alumina, and to oxides of iron in more or less hydrated forms. Following Mr. Scrivenor the laterite can be conveniently classed into siliceous, ferruginous, or aluminous laterite as its composition indicates, whilst the highly aluminous masses present in ~~them~~ it can, in my opinion, be best and most accurately described as bauxite. The above definition would cover not only the aluminous masses to which it has recently been proposed to restrict the term laterite, but also the great majority of these which possess, in parts at any rate, that property of setting from which the name was originally derived. It would also cover the residual lateritic deposits of varying compositions, due to climatic and other conditions, found in different parts of the ~~Indies~~ tropics.

It is not possible in the Guianas to ascribe the production of lateritic deposits to regular alternation of dry and wet seasons. Du Bois gives a table in his work from which I have calculated in inches the average monthly rainfall in Paramaribo, Surinam, for the years 1896 to 1901. This and the average monthly rainfalls during sixteen years at stations in British Guiana situated on laterite are shown in the following:—

Table XXV.

	Surinam. Paramaribo. 1896–1901. Inches of rain.	British Guiana. Mean of 10 inland stations on Laterite. 1891–1906. Inches of rain.
January	5·24	7·06
February	5·61	4·29
March	8·65	7·22
April	8 39	8
May	12·25	11·89
June	11·65	12·45
July	6·37	10·69
August	5·49	7·96
September	2·66	5·22
October	3·45	4·23
November	7	6·57
December	5·49	10
	82·25	95·58

In the dense forests of the Guianas there may be said to be a perpetual wet season, as under the shade of the trees even during periods of comparative drought the land is invariably wet and more or less soaked with water containing organic acids in solution.

The only factor indicated in the Guianas as governing the production of lateritic deposits as opposed to that of pipe-clays is the original composition of the rocks. Rock in which plagioclase felspars with their usual concomitants of ferro-magnesian minerals are abundant, give rise by their decomposition in situ to laterite; those in which alkali felspars are predominant as a rule decompose to pipe-clays or kaolins.

The protective influence on the soils of the very heavy tropical forests which in the Guianas specially characterize the areas of lateritic residual deposits is very great. When the land is cleared of forest denudation rapidly removes the fine constituents of the earths, leaving on the surface the masses of ironstone, bauxite, and quartz. The Christianburg-Akyma deposits show that under conditions of which we have no indication a lateritic decomposition-product may differentiate into angular secondary quartz-sand and into concretions and impregnations of secondary hydrates of aluminium and iron.

It has been repeatedly stated that the production of laterite is confined to countries having hot, moist climates. Positive evidence as to this appears to me to be wanting. That the preservation of lateritic deposits is largely confined to more or less tropical countries I willingly admit, as it is the absence of frost that allows of the accumulation of deep deposits of laterite. The property of hardening or setting when exposed to the atmosphere which these deposits exhibit in parts, although sufficient for their protection under tropical conditions, would be of little effect were the deposits exposed to frost. Under temperate conditions the accumulation of laterite in situ to great depths would be more or less impossible; the residuary matters would be subject to rapid detrition and denudation, their hardening properties would not be developed or only to a slight extent, and what under tropical conditions would form laterite would be redeposited as alluvial detritus, in which the presence of free hydrate of alumina would not be easily recognized.

The majority of the analyses which have been made of such ~~alkaline~~ deposits have been for agricultural purposes, and in such analyses, unless the attack of the dilute acid used is continued for a great length of time, a considerable proportion of the alumina, which is in the form of hydrate, ~~which~~ is resistant to a marked degree to the action of weak acids, will not enter into solution and will be included amongst the sand and insoluble silicates. It is therefore possible that the proportions of alumina present as hydrate have been underrated in many analyses of the clays and earths of temperate countries, and that if analyses were carried out on lines adapted for the determination of the proportion of silica present as quartz, or colloid silica, and in the combined state and of the total amounts of alumina and other bases present, earths with noticeable proportions of other hydrates of alumina would be found not to be of rare occurrence. In connexion with the possible presence of alumina

in the form of hydrate in the earths of temperate countries the investigations by Liebrich of the occurrences of bauxitic material in the Vogelberg and Westenwald (*Zeitschrift für Krystallographie und Mineralogie*, xxiii, p. 296, 1894, and *Chemisches Centralblatt*, 1892, p. 94), where the bauxite was proved to be a decomposition-product of a basaltic rock, and the recent paper on the same subject by J. R. Kilroe (GEOL. MAG., No. 534, p. 534, December, 1908), may be of interest.

My long experience in the Tropics with igneous rocks and their decomposition-products has satisfied me that all questions relating to the degradation of the rocks and the re-arrangement of their decomposition-products may be accounted for by the normally occurring, practically unlimited factors of water, carbonic acid, decomposition-products, including organic acids of vegetable debris, and, above all, duration of time. Geologists and possibly chemists are apt to underrate the decomposing, ionizing, or mass action exerted by even pure water on rocks during very prolonged periods of time—periods which on the geologically very ancient land of the Guianas may have extended over geological ages.[1]

There is no necessity for calling in the aid of the very small quantity of nitric acid supplied by the rainfall, which in British Guiana has amounted to only 9 pounds of nitric acid (HNO_3) per acre per annum according to our monthly analyses of the rainfall carried on continuously for over twenty years. Nor are the small quantities of sulphuric and sulphurous acids derived from the oxidation of pyrites of importance, as in British Guiana pyrites is only present in appreciable quantity in metamorphosed rock, whilst in masses, dykes, and sills of diabase on which wide areas of laterite occur, its presence is practically confined to narrow selvages of the contact rock in even minute quantities.

As far as the studies made in the Guianas go it appears that the cause of the hardening or setting of certain laterites will not be found by chemical analysis. My personal opinion is that it is due in part to changes in the degree of hydration of the hydrated oxides of iron

[1] Some ten or eleven years ago, whilst lecturing on agricultural science, I used the following experiment to illustrate the action of pure water on rocks. Rock powder was prepared from various types of rock by grinding on a bucking plate. About twenty grams of the rock powder was placed in a beaker, and from 100 to 150 cc. of cold, recently distilled water poured on it. To the water thus freed from carbonic acid a few drops of a solution of phenol-phthalin was added. In the course of a few minutes the water commenced to change to purple, and after ten minutes or so had elapsed the depth of colour produced served as a measure of the rates of decomposition of the various rocks by the water. I found that the most readily decomposable rocks were felspar-porphyry and porphyrite, the next being granitite-gneiss, followed by granite and granitite. The basic rocks were more slowly attacked by the water. After standing for some time when the colour of the water had ceased to deepen it was poured or filtered off completely, the rock powder again treated with fresh quantities of the boiled water and phenol-phthalin, when the gradual colourization again ensued. This, if desired, could be repeated many times, using the same rock powder. The experiment well illustrated the action of water free from carbonic acid on the rocks, and its repetition with successive quantities of water to be a mass action. The rates of decomposition of the various rocks thus indicated were found to correspond with the extent of their denudation and degradation on the lower-lying lands of the colony.

and aluminium present and to the gradual conversion of soluble colloidal forms of alumina, of iron peroxide, of silica, and possibly of certain silicates into insoluble modifications during the exposure of the rocks to the atmosphere. The deposition of the hydrated oxides of iron from the dissociation of naturally produced solutions of carbonate of iron is doubtless in many places also a factor in the induration of the laterite in situ.

Weathering and Decomposition of Rock and Soils in the Tropics.

In his investigations on weathering of rocks in the Tropics, Mr. E. C. J. Mohr (Bul. Dept. Agr. Indes Neerland, No. 32, pp. 26, figs. 2, 1909) records the effect of rain-water on freshly ground Tertiary basalt under moist warm climatic conditions as follows:—

The rock was used in three sizes, $\frac{1}{3}$ to $\frac{1}{2}$, 1 to $1\frac{1}{2}$, and 3 to 4 mm. particles. It was subjected to the action of rain-water from July, 1906, to December, 1908, in an apparatus so arranged that in one series the level of the water was above that of the rock particles, and in the other the particles were kept moist by rise of water from below. The principal fact noted in the first series was that the silicic acid corresponding to the decomposed augite and lime felspar was washed out with the soluble bases, while the silicic acid corresponding to the alkali felspar remained behind as kaolin. In the second series, only the silicic acid corresponding to decomposed augite was removed, and the silicic acid corresponding to lime felspar remained behind. (Experiment Station Record, vol. xxii, No. 8.)

Note. Owing to a copyist's error, the figures 8·26, against "Iron Protoxide", incorrectly appear in the analysis of the Tumatumari Laterite (in Table IV on p. 446 of the October number of the Geol. Mag.), and should be deleted, the summation of the analysis being carried out as 100·45, the correct figures.

VI.—On the Classification of the Lower Carboniferous Rocks.

By Cosmo Johns, M.I.Mech.E., F.G.S.

In this communication it is proposed to briefly note the divisions which have been proposed for the Lower Carboniferous Rocks of Great Britain and Belgium; to discuss their validity in the light of the important additions that have been made to our knowledge during the last few years; and to suggest a new classification which, while expressing the physical and faunal changes which characterized that particular time interval, shall be generally applicable and at the same time do justice to the workers who have contributed most largely to our knowledge.

It will be necessary to clearly define what is meant by the Lower Carboniferous. In Staffordshire, Derbyshire, and North-West Yorkshire the line has been drawn at the base of the Ingleborough or Kinderscout Grit or its equivalent. In Scotland the Roslin Sandstone is the dividing line, and in the first and last of the areas mentioned Mr. Kidston[1] has determined the great break between the Upper and Lower Carboniferous Floras to take place at this level. In Derbyshire and North-West Yorkshire a marked change of conditions occurs at the same level, and the Geological Survey in both places drew the line at the base of the massive Grit. By definition, therefore, Lower Carboniferous extends up to the level where the plant break occurs. No one has suggested extending the limits any higher, and to draw the line at a lower level would divorce the Upper Yoredale limestones with their rich coral and Brachiopod fauna from the lower limestones

[1] See Mem. Geol. Surv. Derby. and Notts. Coal-field, 1908, p. 9.

with which they are faunally and physically linked. There should be no difficulty in selecting a name for this great division of the Carboniferous System. The work that has been done by Dr. Arthur Vaughan on the Avon section, and the impetus which the publication of his conclusions gave to the study of the Carboniferous Limestone in this country and abroad, at once suggests the acceptance of the term AVONIAN in preference to Bernician or Dinantian.

For the divisions of the Avonian we have in common use the terms Tournaisian and Viséan. If only in fairness to the Belgian workers who established these divisions, and in recognition of the value of their contribution to our knowledge, these terms should be retained. It has been demonstrated [1] that the line drawn in Belgium corresponds exactly to the physical break in South Wales at the base of the Viséan, and is the well-known C–S level of North-West Yorkshire and Westmoreland. Thus the dividing line between Tournaisian and Viséan is, and can only be, drawn at the same horizon in these widely separated areas.

It is not so easy to define the upper limits of the Viséan, for the Avonian coral and brachiopod fauna persisted longer in some districts than others, but over wide areas it gave place, as a result of physiographic changes, to a new fauna, chiefly cephalopods and lamellibranchs, which persist to the summit of the Lower Carboniferous. It is to Dr. Wheelton Hind we owe the demonstration that this fauna which characterizes the Lower Culm is the same as that of his Pendleside Series. Viséan cannot be made to include this Culm or Pendleside fauna, which can be seen in Derbyshire, Yorkshire, and Lancashire to succeed it.

Upper Carboniferous.		Level of the Plant break.		
Lower Carboniferous.	AVONIAN.	Yoredalian	Upper	Upper Yoredale Coral Fauna.
			Lower	Entrance of Lower Culm or Pendleside fauna (*Posidonomya Becheri*).
		Viséan		Entrance of C–S fauna (*Caninia patula*, *Clisiophyllum Ingletonense*).
		Tournaisian		

The difficulty, however, has been to determine the relationship between the Yoredale rocks of the typical Yoredale district and the Pendleside Series. Reasons have been given [2] for correlating the *Posidonomya Becheri* beds of the Pendleside Series with the Lower Yoredales, and it might be further pointed out that the coral fauna of the Upper Yoredale limestones is an appreciable advance on the D_2 of South Wales. Perhaps even more important is the fact that at the

[1] Arthur Vaughan, Brit. Assoc. Reports, Carboniferous Fauna, 1910.
[2] Evidence for this will be given in the *Naturalist*, January, 1911, p. 9.

top of the Viséan there occurs a well-marked *Cyathaxonia* phase which is generally succeeded by the *Posidonomya Becheri* beds. In the typical Yoredale area the same succession has been observed at the base of the Yoredales. If the equivalence of the Lower Culm, Pendleside, and Yoredale Series be admitted, then a tripartite division of the Avonian is necessary, and for this upper division the work of Phillips in having pointed out the importance of the Yoredales as a distinct division of the Lower Carboniferous should be recognized, and the term Yoredalian employed in our proposed classification, shown on p. 563.

It is obvious that with any classification there will be local difficulties. It is known that in some places the normal D_2 conditions persisted into Lower Yoredale time, or that it was replaced by a development of the 'knoll' limestones. In other areas the *Cyathaxonia* phase is found intercalated with the *Posidonomya Becheri* beds. These difficulties are but local and do not affect the general applicability of the proposed classification.

REVIEWS.

I.—A Descriptive Catalogue of the Marine Reptiles of the Oxford Clay, based on the Leeds Collection in the British Museum (Natural History), London. Part I. By Charles William Andrews, D.Sc., F.R.S. 4to; pp. xxiii and 205, with frontispiece, 10 plates, and 94 text-figures. Printed by order of the Trustees of the British Museum, London, 1910. Price £1 5*s*.

FOR some years past visitors to the Natural History Branch of the British Museum at South Kensington, who have passed through the gallery devoted to fossil reptiles, cannot have failed to be attracted by certain specimens of Plesiosaurians which, on account of their perfect condition and the method of mounting, appear more like modern skeletons than the remains of ancient fossil creatures. These specimens, it is well known, form part of the famous Leeds Collection of fossils from the Oxford Clay of Fletton, near Peterborough. It was Dr. Henry Woodward, when Keeper of the Department, who first interested himself to obtain these remarkable specimens for the British Museum; and his successor, Dr. A. Smith Woodward, has been no less assiduous in securing this unique collection.

It is now several years since the first of the skeletons was placed on view in the Museum cases, and it had been mounted most skilfully and with great patience by the late Mr. C. Barlow. Several other examples have been added more recently, most skilfully set up by his son, Mr. F. O. Barlow, the present formatore. A careful examination of these specimens, even by those who are not specially interested in fossil reptiles, will prove of no little interest, especially if one bears in mind the amount of time, attention, and skill expended in bringing them into their present satisfactory condition.

The greater number of the bones were obtained by Mr. Alf. N. Leeds, of Eyebury, Peterborough, during the last twenty years, but the collecting was begun much earlier by his brother, Mr. Chas. E. Leeds. Mr. Leeds, living near the Oxford Clay pits at Fletton

and other localities near by, had unusual facilities for obtaining the fossils which were unearthed, and lost no opportunity of rescuing them; the greatest care being taken by him to keep the various parts of each individual together and separate from others. The bones were numbered and packed in separate parcels, so that in the end it has been possible to bring together the almost complete skeletons of a number of these animals. Frequently the bones when found were broken in many pieces, and these were reunited by Mr. Leeds with the greatest skill and patience. Subsequently, when the specimens came into the possession of the British Museum, they were mounted with no little ability by the formatore in the Geological Department, and now several of them are to be seen in the Museum cases. Those of us who have examined these wonderfully reconstructed skeletons have long been hoping for some account of them, and at length we have the satisfaction of welcoming the volume which has been published by order of the Trustees of the British Museum, and proves to be a memoir worthy of the institution from which it issues. The work is entitled *A Descriptive Catalogue of the Marine Reptiles of the Oxford Clay*, but although this title may be correct it conveys but little idea of the careful and detailed labour which has been bestowed upon the volume by Dr. Andrews. It is an elaborate memoir, and will in future be the necessary work of reference for the Oxford Clay reptiles of which it treats.

Dr. Andrews, in his Introduction, gives an interesting general account of the collection, and says the perfection of some of the specimens is such that "it has been possible to mount the bones in their natural relations as easily as if they had been obtained by the maceration of a fresh carcass". "A notable instance of this is the fine skeleton of *Cryptocleidus oxoniensis* which is figured on the Frontispiece," reproduced from a photograph. Skulls, it seems, have rarely been found in anything like a perfect condition, and frequently some part of a skeleton, such as a limb, is wanting in an otherwise perfect specimen; from these and similar facts it is argued that many of the bodies must have been dismembered while the bones were still united by the softer tissues. A short account is given of the geological horizon that has yielded this collection of fossils, which is said to be the Lower Oxford Clay of English geologists, characterized by numerous examples of the 'Ornatus' group of Ammonites.

The present volume is only the first part of the entire work, and is restricted to the description of the Ichthyosaurian and Plesiosaurian remains; while Part II, we are promised, will deal with the Pliosaurs and Crocodiles.

The Ichthyosaurian specimens are all referred to one genus and one species, *Ophthalmosaurus icenicus*; and it is pleasing to find that these names, proposed by the late Professor H. G. Seeley (thirty-six years ago), can be retained for them: his keen insight into the details of reptilian osteology enabled him to realize the importance of characters which are still used for their generic distinction. Although only one Ichthyosaurian species is recognized by Dr. Andrews in the present work, he appreciates the large amount of variation to be seen in

different skeletons; due to some extent, no doubt, to age and various stages of ossification, as well as to conditions of fossilization: and he makes the pertinent observation that "If only a few skeletons had been preserved several forms would probably have been recognized and named". But with so large a series before him "it has been found impossible to distinguish more than a single species". Few geologists will be inclined to find fault with this specific restriction, although "future investigations may render possible the diagnosis of others".

The restoration of the cranium of *Ophthalmosaurus* has been an exceedingly difficult matter, seeing that it was largely cartilaginous, and consequently the bones show few or no sutures, or surfaces of actual contact; indeed, but for the fact that in this collection of fossils only one Ichthyosaurian genus seems to be represented, it would have been a wellnigh hopeless task. Numerous specimens, illustrating all parts of the skeleton, are described in detail, and after a short account of the species there follows a catalogue of the very numerous specimens preserved in the Museum.

The Plesiosaurs all belong to the one family of the Elasmosauridæ, characterized chiefly by the scapulæ meeting in a median symphysis which is continuous with the symphysis of the coracoids: and the scapulæ grow inwards (in front) below the clavicles and interclavicles. The clavicular elements become more or less reduced, and it is the variations in this reduction which supply some of the chief characters for the distinction of different genera. Four genera of Elasmosauridæ are recognized: *Muræosaurus*, with three species; *Pierocleidus*, with two forms, only one of which is specifically named; *Tricleidus* and *Cryptocleidus*, each with one species. Of these four genera two, *Muræosaurus* and *Cryptocleidus*, were so named by Professor Seeley, the first in 1874 and the other in 1892; while *Pierocleidus* and *Tricleidus* are genera established by Dr. Andrews quite recently.

The most perfect specimen in this collection is, perhaps, the *Cryptocleidus oxoniensis*, already mentioned as being mounted in the Museum and figured as the frontispiece; and this species has an additional interest inasmuch as it was first described by Professor Phillips in 1871 in his *Geology of Oxford*.

Each genus is separately discussed by the author, and numerous specimens described in detail: the various parts of the skeleton, skull, vertebral column, pectoral and pelvic girdles, and limbs being treated separately and illustrated by plates and text-figures. Following the description of each genus is a brief account of the species referred to it, and a catalogue of the specimens preserved in the Museum.

The volume is liberally illustrated, for besides the frontispiece there are ten lithographic plates and ninety-four figures in the text. Eight of these plates have been drawn by Miss G. M. Woodward with her usual care and artistic finish, and two are the work of Mr. A. H. Searle and are equally worthy of commendation. The text-figures leave nothing to be desired in the way of clearness; but, like so many text-figures in present-day publications, they are far from adding to the beauty of the page; many of them, too, are far larger than is necessary to show the required details; and might almost be called

rough diagrams rather than figures which, while giving the necessary illustration, embellish the page. Modern process-blocks are far from having attained to the perfection which is to be found in many of the old-time woodcuts.

It will be eminently pleasing to palæontologists and, indeed, to all scientific workers to know that the Trustees of the British Museum have added this *Descriptive Catalogue of the Oxford Clay Reptiles* to the long list of their admirable publications. We await with some impatience the publication of the second volume; and in the meantime congratulate Dr. Andrews on this most successful completion of the first part of his valuable work.

E. T. N.

II.—Memoirs of the Geological Survey, England and Wales.

The Geology of the London District (being the area included in Sheets 1–4 of the special Map of London). By Horace B. Woodward, F.R.S. London: printed for H.M. Stationery Office, and sold by E. Stanford, Long Acre, and T. Fisher Unwin, Adelphi Terrace. 8vo; pp. viii and 142, with a small contour-map of the London District. Price 1*s*. Sheets 1–4, price 1*s*. 6*d*. per sheet. 1909.

THIS memoir was issued early in the present year (1910), and is intended to carry on *The Guide to the Geology of London and the Neighbourhood*, prepared by that indefatigable geologist Mr. Whitaker and published in 1875. That work reached its *sixth* edition in 1901, and is now out of print. The four-sheet map now issued, printed in colours (which is less expensive and slightly smaller than that published in 1903), is largely founded on Mr. Whitaker's work, and also on subsequent work by Horace B. Woodward and other members of the Survey.

"No one," says Dr. J. J. H. Teall, "can write on the geology of the neighbourhood of London without being indebted to the work of the late Sir J. Prestwich and of Mr. Whitaker. In the early memoir on *The Geology of the London Basin*, and in the two volumes on *The Geology of London*, Mr. Whitaker not only recorded all the facts gathered during the progress of the Geological Survey, but dealt fully with the observations of other geologists, adding his own criticisms on divergent views . . . Though no effort has been spared by Mr. [Horace] Woodward to acknowledge the sources of information, it has proved to be impossible to do justice to the voluminous literature within the limits of so small a memoir."

The four new sheets which the memoir is intended to explain and describe have each an *inside* coloured area of 18¼ inches by 12¼ inches, with explanation of colours and formations on their outer margin, the scale given being 1 inch to 1 statute mile, their united surfaces covering an area of 36½ × 24½ miles. They are called "Drift Maps", but they really show the extent of the strata or *geological formations* which occur immediately beneath the soil. As examples we may mention the Thames Valley Gravel, the Bagshot Sand, the Thames Valley Brickearth, the London Clay, the Boulder-clay, the Chalk, and the Peat which occurs in the Alluvium of the Marshlands.

"The Chalk forms the foundation of the entire area. It is followed by the Eocene Series, which is represented in and around London by the Thanet Sand and higher divisions up to the Bracklesham and Barton Beds. This series occupies a shallow trough formed by the uplift and bending of the great mass of Chalk so as to constitute what is known as the London Basin; and thus it covers the Chalk from Dartford and Croydon on the south-east to Watford and Rickmansworth on the north-west . . . It is with the Subsoil, not the Soil, except in the case of artificial accumulations of Made Ground, that the Architect, Physician, and the House-Hunter are concerned." (p. 2.)

"The story of London is usually reckoned to commence less than nineteen hundred years ago, when the Britons, who had established a kind of fortified settlement on the rising ground now dominated by St. Paul's Cathedral, were displaced by the Romans (A.D. 43) . . . The Holbourne or Fleet Stream occupied the valley to the west, and the lower part of its course was tidal; while the Wallbrook entered the Thames on the east, above the reach known as 'The Pool'." (p. 3.)

Although on a very reduced scale, the small contour-map which accompanies the memoir gives an exceeding clear idea of the hills, valleys, and streams of the London area, from Rickmansworth in the west to Brentwood in the east, and from Barnet and Enfield in the north to Ewell and Shoreham in the south. An ideal valley, well suited to the needs of its vast population, fed by innumerable streams of sweet water rising from the high grounds north and south, and which, but for the insanitary habits of its mediaeval and later inhabitants, might, as my old friend Dr. G. V. Poore[1] pointed out, have remained in sight the joy and glory of London, but, through constant pollution, they had compulsorily to be put underground, where they still flow in our sewers, serving as our unseen benefactors and sweetening the evils of life.

The history of underground London, geologically speaking, takes us far below the greatest depths of sewers or tube-railways, but is only known through the all too few experimental artesian borings which have been made in various parts of the area of greater London, commencing with the historic Kentish Town boring reported upon by Professor Prestwich[2] and later on by Mr. Godwin-Austen,[3] which reached a depth of 1,302 feet. 188½ feet of red and mottled clays, sands, sandstone, and conglomerates were proved, but their age is uncertain, although most probably Palæozoic. Undoubted Devonian fossils were obtained from a boring at Meux's Brewery, Tottenham Court Road, 1,066 feet from the surface. At Richmond Professor Judd records that fragments of anthracite mingled with Coal-measure sandstone and other Palæozoic rocks were found in considerable abundance, so that we may conclude that the coal under London has really been found, though not in situ.[4]

[1] *London Ancient and Modern, from a Sanitary and Medical Point of View*, by G. V. Poore, M.D., F.R.C.P. (Cassell & Co., 1889), 8vo, pp. 6 and 128.

[2] Q.J.G.S., 1856, vol. xii, pp. 6–14 (1855).

[3] Q.J.G.S., 1856, pp. 38–73; also Proc. Roy. Inst., vol. ii, p. 511. Mr. Godwin-Austen wrote on the boring at Meux's Brewery, GEOL. MAG., Dec. II, Vol. IV, pp. 474–5, 1877.

[4] Q.J.G.S., vol. xl, p. 760, 1884.

A boring by the New River Company at Turnford, near Cheshunt, reached Silurian strata at 796 feet.

At Crossness 52 feet of hard red and grey micaceous and quartzose rocks, red shales, and grey sandstones were met with (suggestive of Devonian rocks), but no fossils are recorded.

At Streatham boring 138 feet of reddish and purplish sandstones of New Red (or possibly Devonian?) age were passed through. Some of these doubtful red rocks may prove to be stained Carboniferous strata, as suggested by Mr. Whitaker.[1] These borings have also yielded rocks of Great Oolite age.

"Thus we find at a depth of 1,000 feet and more under London strata the representatives of which come to the surface about 100 miles distant on the west. There is evidence, however, that the Jurassic strata occur under London in the form of a denuded anticline, as on the west and north-west the Kimeridge Clay, Portland and Purbeck Beds, are the nearest of the exposed Jurassic rocks; on the east, beneath Chatham, the Oxford Clay has been reached, and on the south-east higher Jurassic divisions occur. No representatives of the series are present below Crossness." (p. 8.)

In short we find that the synclinal fold of Cretaceous rocks in which the London Tertiary basin lies, rests upon a denuded anticline of older Secondary rocks whose base consists of Palæozoics of Carboniferous and in part of Devonian and even Silurian strata.

Fifteen sections in the text and a contour-map, with a general geological section showing the relations of the rocks along a line across the London Basin from Watford to near Shoreham, serve admirably to illustrate the Cretaceous and Tertiary Series and their distribution at the surface over the London district as set forth by the author in Chapters III and IV, whilst the faults and disturbances to which these formations have been subjected are described in Chapter V. The surface configuration marked by the Pliocene and older Drifts are considered in Chapter VI, and the Pleistocene and newer Plateau Drifts and Glacial Deposits in Chapter VII. More attention is given to the contours which affect the water-partings and the river-courses, in illustration of which a useful little map by Mr. A. Strahan is introduced on p. 62 to show the Thames and its affluents from the Cotteswolds to the Nore.

The Plateau and Valley Gravels and the Terraces along the river-course have furnished a very interesting chapter in the history of early Man in the Thames Basin (Chapter VIII). We obtain exact evidence of Man in the Palæolithic age, by his various types of flint implements (see figs. 13–16, pp. 79–80), from the high and low level gravels corresponding in relative antiquity with those of La Madélaine, Solutré, Le Moustier, St. Acheul, and from Chelles (Seine-et-Marne) in the French caves and gravel deposits. Moreover, their occurrence has been observed for more than 200 years, "a British weapon found with Elephant's tooth" having been dug up in Gray's Inn Lane about 1690 and since preserved in the British Museum (p. 79). Added to the flint implements left by early Man, as evidence

[1] Address to the Geological Society, Q.J.G.S., vol. lvi, p. 83, 1900.

of his residence in the Thames Valley in prehistoric times, we are also furnished with a long list of the animals (thirty-five are recorded) which he saw and hunted (pp. 76–7), most of which are now extinct or are no longer living in Britain, but which were then indigenous to the London district. In Chapter IX the Holocene or Recent deposits are described, and much interesting information is given as to the wild Mammalia which had their home around British London and in Roman and later times. Some twenty-four species are recorded on pp. 99–100.

Water supply is not neglected (see Chapter X), and some very interesting records are given of old sources of supply. The Metropolitan Water Board have now to provide for a population of nearly seven millions of inhabitants at the rate of 30 gallons, or a little more, per head daily, the daily amount of water required being about 225 millions of gallons (p. 115).

The author in his conclusion reminds us that "the present diversified features are the result of a great series of changes of earth-movements, erosion, and deposition, accompanied by varying conditions of scene, climate, and life; and how the aspect of the country has been modified in later times by the agency of Man. . . . We have further shown how the geological structure has influenced the water supply, and how the different strata have yielded materials of economic value, conducive to the well-being of the community" (p. 132).

We congratulate the author (Mr. Horace B. Woodward), who has followed in the steps of his predecessor (Mr. W. Whitaker) and has produced an excellent and useful memoir upon the area of the greatest and most populous city on the globe. The maps specially deserve commendation, and the price of the maps and the memoir are both extremely moderate.

III.—An Introduction to Petrology. By F. P. Mennell, F.G.S. 8vo. London: Gerrards, Ltd.

THIS little volume of some 200 pages presents an attractive appearance, and in its internal arrangement gives evidence of much thought and an acute appreciation of some of the difficulties which beset an elementary student of petrology. The plan of the work is distinctly good, but unfortunately the chapters do not fulfil the promise of their headings. The first half of the book, which deals with general principles and rock minerals, is the weaker portion, and it is evident that the second half, which treats of rocks and rock structures, was that part of the work with which the author was most at his ease.

It is to be regretted that the earlier portion does not fulfil the purpose that the author intended for it; had it done so, the volume as a whole would have formed a self-contained and most useful guide to the microscopical study of rock-forming minerals and rocks.

In reading the earlier chapters it is impossible to pass without comment such statements as the following, which, if not quite incorrect, must at any rate lead to much confusion. On p. 25 he says: "Every mineral refracts light to a certain extent, that is to say,

makes light deviate from a rectilinear path in passing through it. Now on the undulatory theory light is composed of vibrations of the ether in all possible directions. When, however, it passes through a crystal belonging to any other than the regular system all the vibrations are made to take one or other of two definite directions at right angles to each other and to the direction of propagation. The light is then said to be polarised." There is also much confusion in the use of the terms 'refractive index' and 'indices'. Again, on p. 31 he says: "The mica gives a typical biaxial figure showing two dark hyperbolæ (brushes), which unite four times during a rotation (at the extinction positions) to form a cross of which one arm is broader than the other. The thin arm joins the optic axes. The broad arm is called the bisectrix, in the case of mica the acute bisectrix as it bisects the acute angle between the optic axes." On the following page, speaking of the optical sign of minerals, he remarks: "Some minerals have their interference tints heightened when covered with a quartz wedge having its long axis in the same direction as their own, while others have them lowered. In the first case the sign of the double refraction is said to be *positive*, in the latter it is *negative*." We are left to guess, however, what constitutes the 'long axis' of either the crystal or the quartz wedge. The whole of the introductory portion dealing with the crystalline form and optical properties of minerals is put into twenty pages, and is almost valueless to any serious petrological student. Chapters VII–XI deal with the rock-forming minerals, and these constitute a useful portion of the book. However, it would have been better if the minerals had been arranged according to their crystalline system or their optical behaviour rather than their chemical composition. Their descriptions are often somewhat unscientific, and occasionally there are insufficient data for the identification of a certain species. It is to be remarked that such valuable mensurate constants as the birefringence in anisotropic media are disregarded. Chapters XII–XXI refer to igneous and sedimentary rocks, and the processes and products of metamorphism and weathering. The description of the various simple rock types is by far the best portion of the work, but it suffers from incompleteness, and there is occasionally a lack of definition of rock names and structures. Many of the illustrations are admirable, especially those which are reproduced from line-drawings, but some of the photomicrographs are too smudgy and out of focus to be worth the space they occupy.

H. H. T.

IV.—Some New Geological Maps.

1. Geological Map of Egypt.—We have received from the Survey Department, Cairo, a geological map of the country issued 1910, in six sheets, on the scale of 1 : 1,000,000, on which the various formations are very clearly shown in colour-prints. No record, however, appears of the names of the geologists who are responsible for the field-work. The area extends from the Gulf of Salum and Alexandria to Port Said on the north, and from Wadi Halfa to Ras Hadarba on the Red Sea coast on the south. The southern part of

the Sinai Peninsula is also coloured geologically. Notes of mines and quarries are printed on the map, and the "Gravel Ridges of Quartz and Chert Pebbles with Silicified Trees" are indicated in the Oligocene tract west of Cairo. The famous "Petrified Forest" that occurs to the east-south-east of Cairo occupies a comparatively small area and is not marked. Some account of it was given by Mr. Carruthers in the Geological Magazine for July, 1870 (p. 306).

Another geological map of Egypt, in one sheet, scale 1 : 2,000,000, has also been published by the Survey Department.

2. Oxford Wall Maps.—A series of wall-maps designed to assist teachers of Geography is in course of preparation and publication at the Clarendon Press, Oxford, under the editorship of Professor A. J. Herbertson. The maps are not simply reproductions of existing works, but have been specially prepared with the aid of experts, and drawn by Mr. B. V. Darbishire, M.A. Most of the maps are to be printed without names of places, etc., as these obscure the main features. Such is the case with the specimen before us, "The British Isles, Geology." The scale is 1 : 1,000,000 or about 16 miles to 1 inch. Squares printed in black, alongside the scale, show respectively areas of 250 square miles and 100 square kilometres. The geological groups that are indicated by colour on the map are Igneous, Archæan, Cambro-Silurian, Devonian–Carboniferous, Permo-Triassic, Jurassic, Cretaceous, and Tertiary. Coal-measures are printed in black, and the other Carboniferous strata are distinguished from Devonian by cross-ruling. Magnesian Limestone, Oolite Limestone, and Chalk are indicated in a general way by cross-ruling. The colour-printing is clear, and although there are some slight differences in shade between the northern and southern halves of the map (which have been separately printed), they are hardly noticeable at a distance. The map, which includes the adjacent portions of France and the Channel Islands, should be a very useful diagram to a teacher versed in geology, especially if provided also with a map of the physical features and a series of geological sections. The price of the geological map is 7*s.* unmounted, 8*s.* 6*d.* mounted on cloth to fold, and 10*s.* 6*d.* on rollers.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 9, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Rhætic and Contiguous Deposits of West, Mid, and Part of East Somerset." By Linsdall Richardson, F.R.S.E., F.L.S., F.G.S.

This paper contains a detailed account of the Rhætic strata of Somerset, with the exception of a small area bordering upon Bristol. The magnificent sections at Blue Anchor and Lilstock are described in detail, and correlated with those on the opposite Glamorgan coast. The record by Professor Boyd Dawkins of characteristic Rhætic mollusca in the top portion (uppermost 14 feet or so) of the Grey Marls is confirmed, and the contention for their recognition as Rhætic

is fully substantiated. The deposit between the top of the fossiliferous Grey Marls or 'Sully Beds' and the main Bone-bed at Blue Anchor measures 22 feet, and teems with interesting Rhætic fossils, such as *Pteromya crowcombeia*, Moore. The beds above the Bone-bed agree very well with those occupying the same stratigraphical position in Glamorgan, and include the 'Upper Rhætic', the equivalent of the White Lias proper, and the 'Watchet Beds'. The now obscured magnificent sections, that were temporarily to be seen in the railway-cuttings at Langport and Charlton Mackrell, briefly noticed by Mr. H. B. Woodward, are described in detail (the records being made in company with Mr. E. T. Paris, F.C.S.). Here huge boulder-like masses of rock were noted at the top of the Black Shales, and the White Lias proper, with a well-marked Coral Bed, totalled 25 feet in thickness. The classic sections of Snake Lane, Dunball (Puriton), Sparkford Hill (Queen Camel), Shepton Mallet, and Milton (Wells), have been re-investigated and brought into line; and the interesting thin Rhætic deposits in Vallis Vale, at Upper Vobster, and sections in the Radstock district, and on the Nempnett and neighbouring outliers, are described. In addition to the record of many new or imperfectly known sections, this investigation has also shown that the *Microlestes* Marls are equivalent to the Sully Beds: that the Wedmore Stone occurs well below the Bone-bed; that Moore's 'Flinty Bed' at Beer Crowcombe is probably on the horizon of the *Pleurophorus* Bed (No. 13); that the Upper Rhætic (generally with Cotham Marble or its equivalent) is as persistent as usual, if not quite so thick; that the White Lias proper is of restricted geographical extent; and that on the Bristol Channel littoral are marls, 'Watchet Beds,' above the White Lias. Around Queen Camel, Moore's 'Insect and Crustacean Beds' appear to come in at an horizon which lies between the Watchet Beds and the *Ostrea* Limestone.

The following classification of the Rhætic Series is suggested, and the succession of maxima of the characteristic fossils is given in the paper:—

			Thicknesses in England.
Lias.	Hettangian.	*Ostrea* Beds, etc.	
Rhætic	Somersetian	I. Watchet Beds ('Marly Beds of the White Lias')	0 to 7 ft. 7 in.
		II. Langport Beds (White Lias proper)	0 to 25 ft.
		III. Westbury Beds ('Upper Rhætic')	2 ft. 9 in. to 19 ft.
	Rhætian	IV. Lilstock Beds (Black Shales)	1 to (?) 47 ft.
		V. Sully Beds (Fossiliferous Grey Marls)	0 to 14 ft.
Keuper	Keuperian	Tea-green and Grey Marls . .	111 ft. (max.).
		Red Marls.	

The sudden lithic and faunal changes in the contiguous divisions are held to be the expression of oscillatory movements and interrupted sequential deposition. The fauna of the Rhætian is decidedly Swabian in facies, and the general conclusion to be derived from the study of the beds is in entire agreement with Suess's view, that while the dominant movement was one of subsidence and not local but extended, it was, nevertheless, "oscillatory and slow."

2. "Jurassic Plants from the Marske Quarry." By the Rev. George John Lane, F.G.S.

The Marske Quarry is situated on the northern side of the Upleatham outlier in the Cleveland district of Yorkshire. It is about 500 feet above sea-level. In the quarry several varieties of rock are exposed, namely shales, small coal-seams, sandstones, and a ferruginous bed. The beds are of Lower Oolite age, and belong to the Lower Estuarine Series. As the Millepore Bed is absent in the district, the Lower Estuarines and the Middle Estuarines may be one continuous deposit. From this quarry *Dictyozamites* was recorded for the first time in England, its occurrence being made the subject of a paper presented by Professor Seward to the Geological Society in 1903. The writer has obtained nearly forty species from the quarry, among which are many characteristic Wealden plants. This discovery is most interesting, especially when one considers the vast interval of time that elapsed between the horizons of the Inferior Oolite and the Wealden.

CORRESPONDENCE.

THE ORIGIN OF THE BRITISH TRIAS.

Sir,—In reply to your correspondent Mr. W. B. Wright,[1] of the Scottish Geological Survey, who has doubtless heard much of the Desert theory from his former colleague, Mr. T. O. Bosworth (who has so ably described the evidences of desert conditions in Leicestershire), Mr. Wright must know that it is unusual to criticize an abstract[2] before the full text of the paper is printed. I shall therefore be as brief in my reply as I was in the abstract, only quoting the numbered passages from Mr. Wright's letter. I may reply—

(3) I do not speak of a general absence of delta-bedding, for see (9). It *does* occur. Professor Bonney is cited by me as proving the delta origin of the Bunter, and I do not propose here to add one iota to his evidence. It is quite clear enough, and the Survey Library contains the papers in which Professor Bonney published his proofs. The dactyloid form is just a further point of analogy, and the extension of the Trias delta-head is suggested by evidence from deep borings (as to which let Mr. Wright ask Mr. Whitaker, who will also give him all the bibliographical assistance he needs, as he kindly did for me) in the East and South-East of England, chiefly made in connexion with explorations for coal.

(9) It would be equally as fruitless as trying to find the river-bed of the Triassic delta (or its tributaries) to expect to show beds in the act of tilting through an angle of 45°; but it is an axiom of modern physical geography (which I merely extend to the past) that beds when subsiding do tend, when so elevated, to become horizontal finally. The discontinuity of delta-bedding, laterally and vertically, seen so clearly in Staffordshire and Notts., is an ocular demonstration of what has happened in the past; but no more is to be expected. The characteristic overlapping, of which Mr. Wright must have

[1] See Geol. Mag. for November, 1910, p. 526.

[2] See "Origin of the British Trias", by A. R. Horwood (Abstract of paper read at the British Association, Sheffield, September, 1910): Geol. Mag., October, 1910, p. 460.

seen something in Notts., gave rise in early Survey days to the interpretation of certain sections of strata so juxtaposed as faulted beds. Viewed as delta-bedded deposits the faults disappear, and such instances can perfectly well be illustrated on a map just as the discontinuous bedding.

(16) Rocks polished by wind-action occur at various points at Mount Sorrel, Croft, and elsewhere. These older pre-Triassic rocks are at practically the same level as O.D., and the Trias was laid down just as we now find it, with a slight dip, allowing for subsidence. It is merely a *petitio principii* to say cases for observing wind-polishing are very exceptional. But it is very damaging evidence for the desert theory to show that this action occurs only where red marl abuts against older rocks *and along a single horizontal line*. This illustrates the local (littoral or marginal) character of desert action in Triassic times.

(20) A reference to Professor Hull's Survey memoirs and Professor Bonney's papers will give Mr. Wright the information he desires.

(21) The nature of the heavy minerals of the Bunter, Keuper, and the Nile indicates that they have a common character and in their several areas a common origin to a great extent. It is known that the Nile delta deposits are mechanically altered, owing to their having been, in part, derived from a contiguous desert. In the Nile the water is free from those chemical agents which ordinary river- or rain-water contain, so that chemical action is absent. In the Trias river and rain have acted in such a way during the past that the marls of the Upper Keuper exhibit their effect. This point is another corroborative of the aqueous origin and, together with other indications, of the delta origin of the Trias.

A. R. Horwood.

Leicester Museum.
November 14, 1910.

OBITUARY.

JOHN ROCHE DAKYNS, M.A.

Born January 31, 1836. Died September 27, 1910.

J. R. Dakyns, the eldest son of Dr. Thomas Henry Dakyns, was born in the island of St. Vincent, West Indies. In 1845 the family removed to England, and settled at Rugby, where J. R. Dakyns received his early education. In 1855 he proceeded to Trinity College, Cambridge; four years later he gained the position of twenty-seventh Wrangler in the Mathematical Tripos; and during the next two years he was engaged in teaching. Mathematics was a subject at all times of great interest to him, but Physical Geography likewise had its attractions. Hills and mountains exerted a magnetic influence on him, and the contemplation of these great features probably led him to the study of Geology. Eventually he found a congenial outdoor profession on the staff of the Geological Survey. He joined as an Assistant Geologist on January 16, 1862, and was promoted to the rank of Geologist on January 1, 1868.

In the course of his field-work he was principally occupied in the West Riding of Yorkshire and bordering tracts of Derbyshire, Lancashire, and Westmorland, and for a few years in the East

Riding. The results of his labours are given on the Geological Survey maps, and (as part author) in the memoirs on North Derbyshire (1869), the Yorkshire Coal-field (1869 and 1878), Leeds and Tadcaster (1870), Dewsbury, Huddersfield, and Halifax (1871), the Burnley Coal-field (1875), Bradford and Skipton (1879), Bridlington Bay (1885), York and Hull (1886), Driffield (1886), Kendal and Sedbergh (2nd ed., 1888), Ingleborough (1890), Mallerstang (1891), and Appleby (1897). On the mountains and uplands of the Lower Carboniferous rocks Dakyns was in his element, whereas when surveying for a time in the lowlands of Holderness he was by no means so buoyant in spirits. On the completion of the 1 inch geological map of England and Wales in 1884 he was transferred to the Scottish branch of the Geological Survey, and was engaged for ten years in mapping parts of the Forest of Athole, the country westwards to the borders of Argyllshire, and that around Loch Lomond in the counties of Stirling and Dumbarton. So far as mountain scenery was concerned Dakyns was in a kind of paradise, but the uncertainties of the geology sorely taxed him, and he was heard on one occasion to remark that hell was paved with Highland schists.

In conjunction with Dr. Teall he communicated to the Geological Society in 1892 an important paper "On the Plutonic Rocks of Garabal Hill and Meall Breac".

In 1894 Dakyns was transferred to South Wales to take part in the re-survey, on the 6 inch scale, of the Coal-field and bordering rocks. There he rejoiced in mapping the hilly ground of Old Red Sandstone and Lower Carboniferous rocks around Abergavenny, and he contributed to the memoir on that area, which was published in 1900.

He retired from the Geological Survey on April 30, 1896, soon after attaining the age of 60, and took up his residence at Snowdon View, Beddgelert, where he spent a pleasant and happy time geologizing in that mountain region. He re-mapped on the 6 inch scale the greater part of Snowdon, together with much of the adjacent country; and his maps and notes embody important revisions and additions to the knowledge of the district. It is much to be desired that this work should see the light; and as one of his intimate friends is, we understand, about to complete the parts left unfinished, we may hope that this will be accomplished before long. Through the results of a chill his active life was terminated after a brief illness, in his 75th year.

Although he never became a Fellow of the Geological Society, Dakyns communicated to that Society in 1872 a paper "On the Glacial Phenomena of the Yorkshire Uplands"; he was a frequent contributor to the Geological Magazine, on subjects relating more especially to Carboniferous and Igneous rocks, to Glacial Phenomena and Cave-deposits, and he was author also of papers published by the Yorkshire Geological and Polytechnic Society. Extremely original in character, and very widely read, intercourse with him possessed unusual fascinations; moreover, being full of sympathy for all living beings, and a staunch friend, he was endeared to all who had the privilege of his acquaintance.

H. B. W. & E. G.

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